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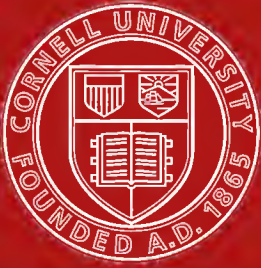
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MISSOURI GEOLOGICAL SURVEY

VOLUME VII.

LEAD AND ZINC DEPOSITS

(SECTION 2)

By **ARTHUR WINSLOW**

ASSISTED BY **JAMES D. ROBERTSON**

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STATE GEOLOGIST



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LETTER OF TRANSMITTAL.

MISSOURI GEOLOGICAL SURVEY, }
JEFFERSON CITY, JULY 1, 1894. }

*To the President, Gov. Wm. J. Stone, and the Members of the Board of Managers of the
Bureau of Geology and Mines :*

GENTLEMEN—I have the honor to transmit herewith the second section of the Report on the Lead and Zinc Deposits of Missouri, by Mr. Arthur Winslow, assisted by Mr. James D. Robertson, and to remain,

Your obedient servant,

CHARLES R. KEYES,
State Geologist.

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CHAPTER X.

GENERAL GEOLOGY.

(Continued.)

THE LOWER CARBONIFEROUS—THE COAL MEASURES—THE TERTIARY—THE QUATERNARY AND
RECENT—STRUCTURAL GEOLOGY.

LOWER CARBONIFEROUS.

The Lower Carboniferous, or Mississippian series of rocks, is sparsely represented in all excepting the Southwestern district. In the southeast, there is a mere marginal strip beyond the mining area, and of no direct association with it. This strip has not been specially studied by the present Survey, and little or nothing has been added to what is said concerning it in earlier reports. We shall hence pass it by without further mention. In the Central district, about the same conditions exist. Some additional mapping has been done, and sections have been measured in the western part, along the Osage river. The results of this work are included in the sections of the Lower Silurian already given. Rocks of both the Augusta and Kinderhook stages are represented. They rest somewhat unconformably upon the underlying magnesian limestones. Patches of Lower Carboniferous limestones and detached blocks are seen at intervals over the district, beyond the main areas. Some of these are shown on the map, but many are too small to be represented. They are sometimes associated with ore bodies. They indicate former extension, and are, hence, significant.

THE SOUTHWESTERN DISTRICT.

Lower Carboniferous rocks are the prevalent ones of the Southwestern district; in them all the important ore deposits occur. Owing partly to a westward dip, but also probably to a deepening of the basin, the maximum thickness is in the western portion of Jasper county, while along the eastern margin the lowermost beds are exposed. The divisions of the Lower Carboniferous series recognized in the State, according to the grouping of Dr. Keyes, are as follows:

TABLE OF LOWER CARBONIFEROUS FORMATIONS OF MISSOURI.

Series.	Stages.	
Lower Carboniferous or Mississippian.	Kaskaskia.	Chester shales. Kaskaskia limestone. Aux Vases limestone.
	St. Louis.	St. Genevieve limestone. St. Louis. Warsaw (in part).
	Augusta.	Warsaw (typical). "Geode bed." Keokuk limestone. Upper Burlington limestone. Lower Burlington limestone.
	Kinderhook	Chouteau limestone. Hannibal shale. Louisiana limestone.

The rocks of the southwest belong principally to the Augusta and Kinderhook stages, reaching from the Louisiana limestone upward, probably to the Keokuk. Fossils have been found indicating the presence of the St. Louis, and even of the Kaskaskia limestones, but these occur at isolated localities, and the evidence they afford is not sufficient to establish the presence of the formations.

The basal limits of the Lower Carboniferous are the Lower Silurian magnesian limestones, or the Devonian shales just described. The lower contact is unconformable. At the top are beds of the Coal Measures, the contact being also unconformable to such a degree that the latter beds may rest upon any Lower Carboniferous rocks, from the Kinderhook to the Keokuk.

Distribution.—The distribution of the rocks of this series is clearly shown on the map and need not be further described here. Concerning the marginal lines and outliers, the remarks made on p. 338, in connection with the distribution of the Silurian rocks, are to be applied here also.

Lithology.—The rocks of the series are limestone, cherts, shales and sandstones.

Limestones.—The limestones are by far the most abundant. Of these, the more prevalent are the white or gray, coarsely crystalline

beds, containing abundant crinoid stems and other fossils. They belong mostly to the Burlington, though possibly also to the Keokuk in some instances. They occur in massive beds, and are extensively quarried for lime-making and for building-stone. They are frequently exposed in prominent bluffs. Denser and finer grained limestones are also found; such especially characterize the Kinderhook stage—the Louisiana limestones being frequently of this character, and thinly bedded.

The massive, crystalline beds are remarkably pure, and are well adapted to the making of lime. They are rarely magnesian, and this, generally, only near the ore deposits, as the result of secondary action. The lowermost beds appear to be more magnesian than the others. The table of analyses of the next page is principally of rocks of this formation in southwestern Missouri.

Shales and Sandstones.—The shales are generally drab or bluish, and are frequently calcareous; they are most abundant near the base of the series.

The sandstones are confined almost entirely to the Hannibal sub-stage, and consist of reddish, friable rock, with characteristic fucoid markings, which have given it the name of vermicular.

Cherts.—The cherts are normally in lenticular layers, or in isolated nodules strung out along the bedding-planes. Sometimes, beds 2 ft. or more thick are found, but these are exceptional. These cherts are generally of a white or bluish color, sometimes translucent, of homogeneous composition and texture, with a sharp conchoidal fracture, often shattering into hundreds of fragments with a blow of the hammer. Certain beds of red, granular and somewhat porous chert, resembling quartzite, are also found. At Seneca is a bed nearly 20 ft. thick, of soft, friable, siliceous material, called tripoli, which is a decomposed chert. At some localities, especially along Shoal creek, very massive strata of chert are encountered, 20 or more feet thick. This rock is peculiarly gnarled and very tough; it is not typical Lower Carboniferous chert.

On the whole, the chert of this formation differs from that of the magnesian limestones, in that the layers are thinner, the texture more dense and homogeneous, and the masses more regular in distribution and outline. Further, the Carboniferous chert is more fossiliferous, being specially rich in crinoid stems. The chert, in such cases, generally fills what were originally cavities in the stem, so that when the limestone is removed interior casts remain. In some instances, however, there is undoubted replacement. A close association or inter-

FIG. 1.



FIG. 2.

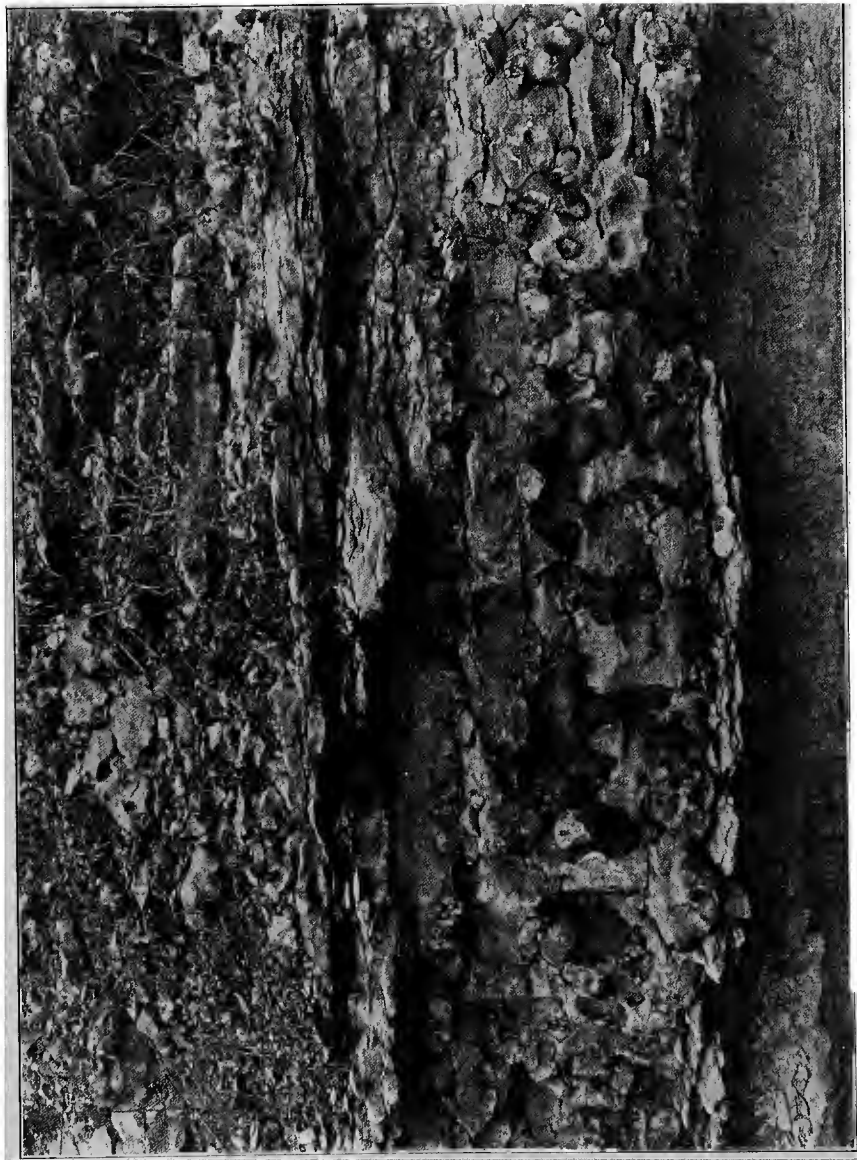


LOWER CARBONIFEROUS CHERTS.

FIG. 1 GRAND FALLS VARIETY.

From photograph by W. P. Jenney.

FIG. 2. LENTICULAR VARIETY.



NODULAR CHERT IN LOWER CARBONIFEROUS LIMESTONE.
From photograph by W. P. Jenney.

mingling of chert and limestone is noticeable here, as in the magnesian series. Some hard, glassy cherts, with characteristic conchoidal fractures, are distinctly calcareous from diffused lime.

A microscopic study of both these Carboniferous cherts and of the Silurian cherts of the state, has been made by Dr. E. O. Hovey. The results are contained in appendix A, where the analyses by the Survey are also introduced. The field observations and partial microscopic and chemical examinations made by the writer are confirmatory of Dr. Hovey's conclusions that the greater portion of these cherts were formed at the time of the deposition of the rocks; or at least immediately after, before the consolidation of the latter. The action was, doubtless, partly a segregating process, and possibly some replacement or substitution of the lime was effected at the same time. A strong reason for assigning this early date to the formation of the cherts is the manner in which the interior cavities of fossils are filled with that material. Were this by a replacement of lime, we should expect the whole fossil to be changed. Apparently, the silica was deposited in the cavities before the rock was consolidated. The fact that fragments of chert, derived from immediately subjacent beds, are found in Silurian sandstones is another reason, already adduced.

It is difficult to conceive how such great masses as the Grand Falls chert could be formed by replacement, while the overlying and underlying limestone beds remain so little affected. It is difficult to understand how such intimate mixtures of chert and limestones as are represented in the so-called "silico-calcites" of Schmidt, later described, could be formed by secondary changes.

In some cases, there are indisputable evidences of substitution. Such are the silicified shells of fossils which are occasionally found. The isolated nodules and the thin nodular layers in the lower Carboniferous rocks are, possibly, also formed by a later segregating action. Evidences of great silicification, long after the formation of the rocks, are plainly apparent in the ore deposits, and, doubtless, some of the so-called cherts were formed at the same time.

Stratigraphy and Sections.—Throughout the southwestern area are numerous exposures in bluffs and quarries; further, many shafts have been sunk for prospecting and for the development of ore deposits; and, in search of artesian water, a number of deep drill-holes have been put down. From such data a large number of sections have

been constructed, which we will now proceed to describe. We will take these up, so far as practicable, in order from east to west.

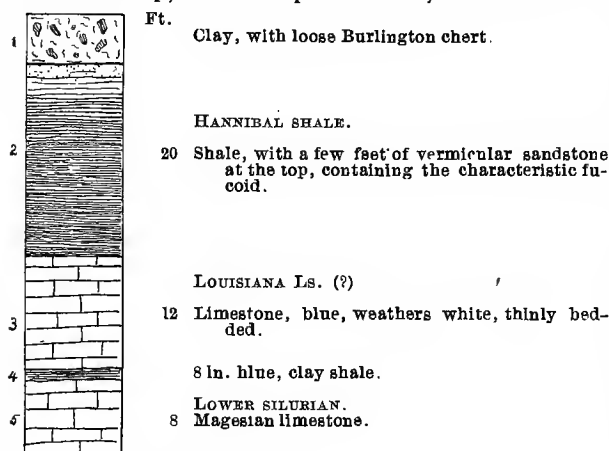


FIG. 72 Section near Cedar Gap.

Cedar Gap and Vi-
cinity.—Cedar Gap
is near the extreme
eastern margin of the
formation. East of
the railway station,
for a distance of
some two miles, are
a series of excellent
exposures in several
cuts. From these
Prof. Rowley con-
structed the section
of figure 72.

Fossils from No. 2 were: *Spirifera marionensis*, *Spirifera clarksvillensis*, *Cyrtina acutirostris*, *Athyris hannibalensis*, *Orthis missouriensis* (Swallow), *Pleurotomaria* sp.?, *Euomphalus* sp.?, *Loxonema* sp.?, *Bellerophon* sp.?, *Orthoceras* sp.?, crinoid stems, and a possible *Chonopterium* sp.?

Fossils No. 3 were: a small blastoid, probably *Pentremites (granatocrinus) sampsoni* (Chouteau species), *Spirifera* of the Lineata group, a small *Productus*, a *Platycrinus*, a *Platyceras* sp.?, a large *Loxonema* sp.?, several imperfect and indeterminate *Actinocrinoids*, *Platycrinus* sp.?, *P. allophylus*, *Amplexus* sp.?, a small *Zaphrenitis* sp.?, *Orthis missouriensis* (Swallow), a small *Spirifera* and a little *Obolites* sp.?

Prof. Rowley assigns No. 2 to the "Vermicular" or Hannibal shales. Of No. 3, however, he states: "it is undoubtedly a member of the Kinderhook or Chouteau stage, and, as it underlies the Vermicular shale, the inference is that this lower limestone is the Lithographic (Louisiana); but the fossils here bear a stronger resemblance to the forms of the Chouteau limestone which belong *above* the Vermicular."

West of here, about Seymour, and north of that place, Mr. Marbut describes a number of occurrences of the Hannibal sandstone, and of the Louisiana limestone, of about the same thickness; still farther west, about a mile south of the county poor-house, near Marshfield, he measured the section of figure 73.

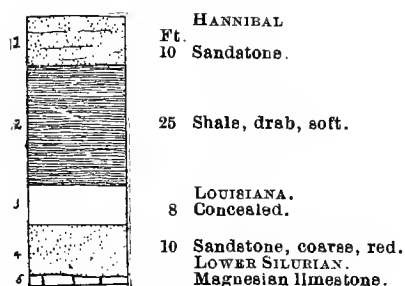


FIG. 73. Section near Marshfield.

field, Mr. Marbut describes the same sandstone as cropping out for a considerable distance; it is there in the vicinity of 30 ft. thick, and of coarse texture and red color. Elsewhere he notes a chert bed in its place. Prof. Shepard describes it as forming the bed and boundary bluffs of James river, almost as far south as Turner's. The age of this sandstone is doubtful; it is apparently unconformable with the underlying Silurian (Lower) magnesian limestones; but that it belongs to the here immediately overlying Lower Carboniferous beds cannot be affirmed; it may belong to the Upper Silurian, or to some other intermediate horizon.

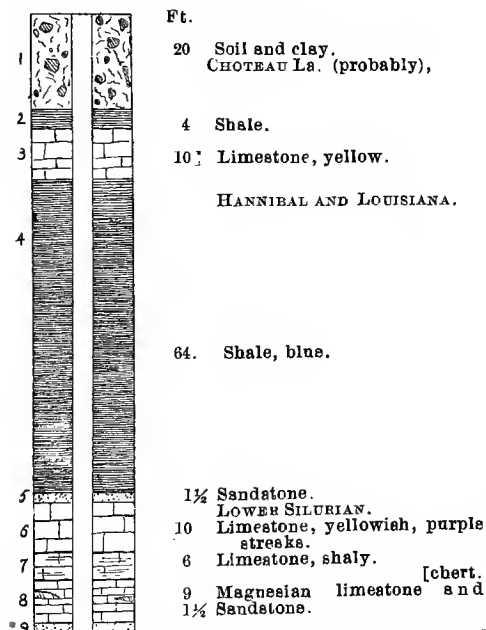


FIG. 74. Section of the Marshfield Mining Co's shaft.

The sandstone (No. 4) is the basal member, and is here exceptionally thick; it has already been referred to in the description of the Lower Silurian; it appears to rest unconformably upon the underlying rocks. Just north of this point, it apparently reaches a thickness of 40 ft. On the main fork of James river, about six miles southwest of Marsh-

field, Figure 74 is a section of the Marshfield Mining company's shaft.

At the Phelps mine, on Pier-son creek, the Burlington beds constitute the mass of the hills, while along the base and in the valley the Kinderhook beds are exposed, or are penetrated by shafts.

Springfield.—In and about the city of Springfield are a number of excellent exposures of Lower Carboniferous limestone, in cuts and quarries. A special study of these for the purpose of determining the age of the rocks was made by Mr. Rowley, with the following results:

"At the corner of Olive and Main streets is an outcrop less than 20 ft. thick. The rock is a hard, bluish gray limestone, and the top layer is much weathered. Near the bottom, *Spiriferi grimesi*, *Athyris incrassata* were found; at 12 ft. from the bottom, *Pentremites elongatus*; at 15 ft. a number of specimens of *Granatocrinus* (probably *G. granulatus*), also some small undetermined species of *Batocrinus*, radial and basal stems of *Platycrinus*, spines of a *Dorycrinus*, and imperfect specimens of *Batocrinus nashvilleæ*, *Batocrinus trochiscus*?. Joints of crinoid columns of *Platycrinus* are numerous."

"The second outcrop was an abandoned quarry at the corner of Campbell and Water streets. The same species were found here."

"The third locality was a long quarry at the west end of College street. To the list above given were here added *Zaphrentis centralis*, a very large *Agaricocrinus* sp.?, basal cups and radial plates of a very large *Platycrinus* sp.?, and great elliptical stems of the same genus. Two large bodies of an *Actinocrinus*, one nearly three inches long, were also seen."

At the lime-kiln quarry, on the Chadwick branch railway, one mile east of the public square, gray limestone is exposed in thick beds. In the bottom layers Prof. Rowley found and identified *Spirifera grimesi*, *S. pseudo-lineata*, *Productus symmetricus*?, *Zaphrentis centralis*, a huge *Aviculopecten* sp.?. At the top of the quarry, the small *Batocrinus* sp.? of the first outcrop, a smooth, rounded *Batocrinus* sp.?, a small, imperfect *Rhynchonella*, a crushed body of an undetermined *Platycrinus* and a *Tricoelocrinus wortheni* were obtained. Broken specimens of *Calceocrinus* sp.?, a *Granatocrinus granulatus*?, *Pentremites elongatus*, *Batocrinus* (like *B. roladentatus*) were also obtained from this quarry. All of the rock is very crinoidal, and especially the upper stratum.

A heavy bed of stratified chert seems to cap all of these outcrops. In general appearance, Prof. Rowley remarks, they strongly resemble the Upper Burlington of eastern and northeastern Missouri, and the presence of *Pentremites elongatus*, *Spirifera grimesi*, *Athyris incrassata* and the *Platycrinus* columns strengthens this resemblance.

At the quarry at the south end of Campbell street, from an exposure of about 5 ft., *Spirifera grimesi*, *Athyris incrassata* and spines of *Dorycrinus* were obtained.

Among Prof. Shepard's collection at Drury College, Prof. Rowley identified the following species, assigned by Prof. S. to the so-called

Cherokee group of Dr. Jenney's; they were collected in Springfield and Ash Grove: *Dorycrinus parvus*, *Batocrinus trochiscus*, and *Physetocrinus ventricosus*, all Upper Burlington fossils. The most striking species, Prof. Rowley writes, were three gigantic Actinocrini, several specimens of a large Agaricocrinus (probably *A. wortheni*), an Eretmocrinus, *Batocrinus pyriformis*, and a number of *Pentremites elongatus*. "The branchiopods, with the exception of a large Streptorhynchus, are characteristic Burlington forms. There were also a few fish-teeth. An Archimedes sp.?, from the chert overlying the Burlington, either indicates a change to the Keokuk, or is an undescribed Burlington fossil. I found a similar specimen in the chert at Curryville, Mo."

In Springfield, several churn drill-holes have been sunk, starting in the Burlington limestone. One of these is at the Electric Motor plant, on the corner of Phelps Ave. and Main street. Samples of the drillings collected by Prof. Shepard were examined by Mr. Robertson. The results are expressed in figure 75.

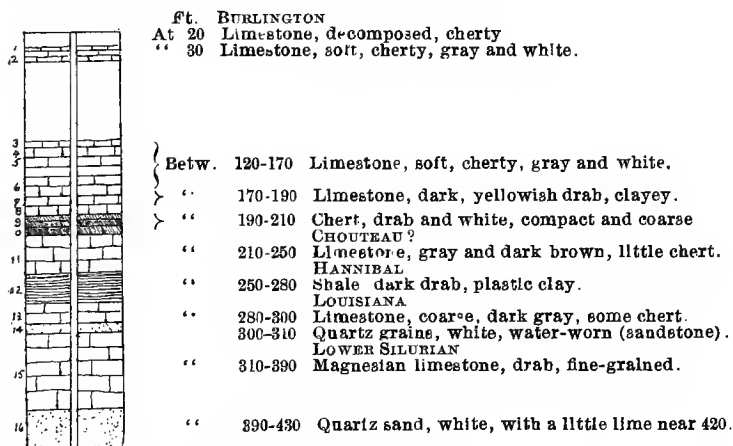


FIG. 75. Section of electric motor plant drill-hole.

Northwest of Springfield, the Burlington limestone covers the surface, and the Kinderhook beds are found only at the lower levels.

Ash Grove and Vicinity.—At Ash Grove, the Burlington beds are principally quarried, and they are frequently exposed in bluffs; but the Chouteau limestone was recognized by Keyes along the branch east of the town, and elsewhere by him and by Rowley. The buff-colored bed at the base of the limestone quarry west of the town is probably Lower Burlington.

In the railway cut east of town, Prof. Rowley found a few feet of hard, white limestone. In this, the fossils, though not scarce, were difficult to obtain in good condition. He recognized *Strotocrinus subumbrosus*, *S. regalis*, *Physetocrinus ventricosus*, *Ollacrinus robustus*, *Batocrinus pyriformis*, *Dorycrinus missouriensis*, *Spirifera grimesi*. This exposure he characterizes as well-marked Upper Burlington.

On a later page of this report, a record of the Pennsylvania company's shaft at this place is given. This attained a depth of 250 ft., passing through probable Kinderhook beds, through the contact sandstone and into the underlying magnesian limestone.

The White River Country—Along the southern margin of this formation, above the White river valley, the Lower Carboniferous rocks are frequently exposed, and a number of sections have been measured. In section 2 or 3, township 24 N., 16 W., Dr. Shumard describes the section of figure 76 [33, p. 191].

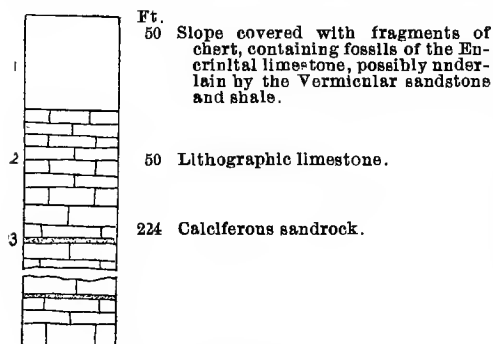


FIG. 76 Section in township 24, N 16 W.

No. 2, Dr. Shumard divides into two parts, one consisting of a compact, fine textured limestone of a light gray color, the other more friable and crystalline, and containing in part an abundance of crinoid remains.

In the vicinity of Ozark, Mr. Marbut describes the sequence of rocks illustrated in figure 77.

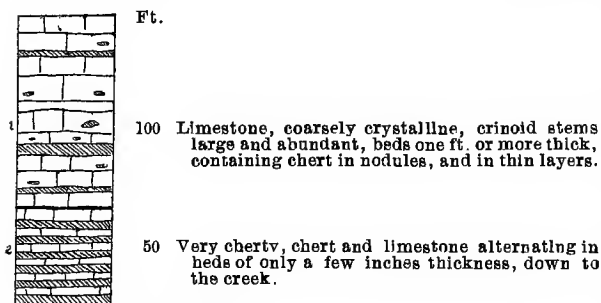
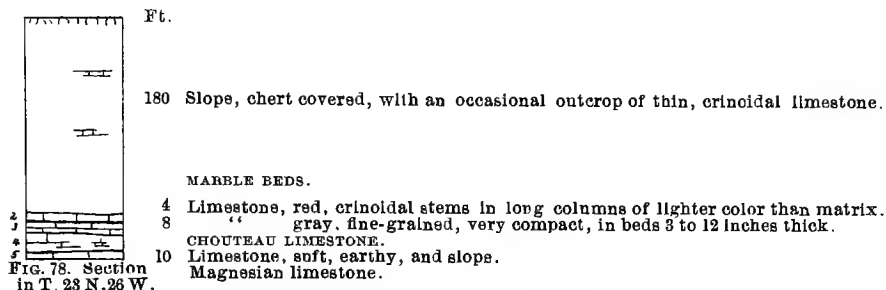


FIG. 77. Section near Ozark.

The town of Ozark is built on a bench, the top of which corresponds about with the top of the cherty beds of this section.

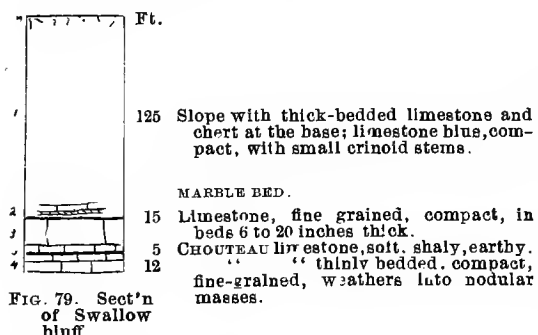
The best sections measured by Mr. Marbut were in east-

ern Barry county. In section 17, township 23 N., 26 W., figure 78 was obtained, from measurements down a steep slope.



The marble beds of the above section constitute a well-defined and easily recognized group of rocks in this portion of the country, and the horizon has been traced by Mr. Marbut from point to point.

In Swallow bluff, on Flat creek, in section 5, township 24 N., 26 W., he measured figure 79.



The contact could not be seen here, but must be immediately beneath the section. No. 3 weathers more rapidly than the other strata, and is thus eroded so that No. 2 overhangs, making a covered foot path. No. 2 sinks beneath the creek bed about a mile up;

thence up the creek the principal beds of the Burlington are exposed, the lower portions being very cherty; the upper, coarse and heavily bedded.

The section of these rocks along Flat creek, from the highest point at Washburn to near the contact with the magnesian limestone, is about as shown in figure 80, according to Mr. Marbut.

This section is based upon a number of observations along the creek. At a few points there is apparently a thick bed of chert, but it is probably only local, in Mr. Marbut's opinion; though, in many places, the chert greatly predominates over the limestone in the lower beds of the section.

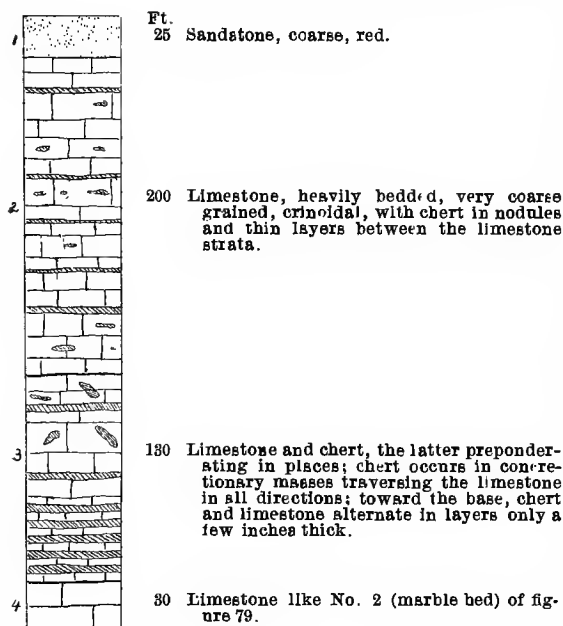


FIG. 80. Section along Flat creek.

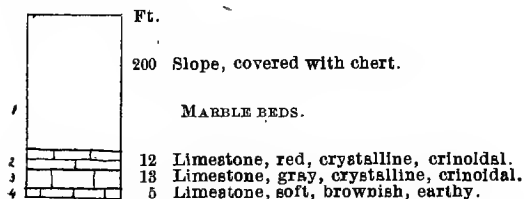


FIG. 81 Section at Rock House cave.

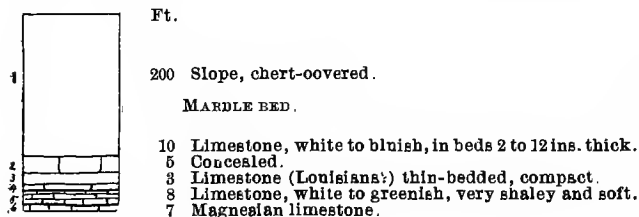


FIG. 82. Section on Wooley creek.

“At Crane postoffice, the cherty beds are exposed in a bluff about 40 feet high; they form a bench on which the village is built.”

“At Long’s mill, on Crane creek, about a mile above the mouth of Spring creek, the top layers of the marble beds are exposed in the bed of the creek.”

“At Rock House cave, in Barry county, section 28, township 23 N., 26 W., figure 81 was exposed.”

“The red marble bed is here about 4 ft. thick. The magnesian limestones crop out a short distance down the branch from the cave.”

“At the head of Wooley creek, in section 3,

township 23 N., 25 W., figure 82 was measured.”

“In section 32 of the same township, the marble beds are exposed 20 ft. or more thick, just above the contact; the red beds are near the top, and are about 5 ft. thick. South of this, along the escarpment, these beds are prominent, forming a precipitous face 20 ft. high. At the base is a narrow terrace known as the bench. Westward from here,

the marble beds become thicker, forming bold escarpments, high up in the hills. They seem to increase in thickness at the expense of the cherty members."

"The isolated hills, lying in the plateau of the magnesian limestones east of White river, are capped with Carboniferous limestones in which are the marble beds of apparently about the same thickness, as elsewhere."

"On Little Indian creek, in section 18, township, 21 N., 23 W., the marble beds are exposed in a bluff, and are here about 25 ft. thick. They are overlain by the cherty beds and loose chert. This section was not examined closely for the red beds. They were seen in section 21, township 22 N., 23 W., but their thickness was not determined."

"The face of the escarpment, from here on eastward, is covered in most places with chert, to and beyond the base of the Carboniferous rocks. The marble beds do not show in steep, high precipices. They crop out, though not entire, in section 26, township 22 N., 22 W. On ascending one of the small creeks, to near the head, they are seen with their usual thickness. On the state line, where Turkey creek crosses it, they are 20 or 30 ft. thick, overlain by 150 of the cherty members of the series. In the NW. $\frac{1}{4}$ of section 22,

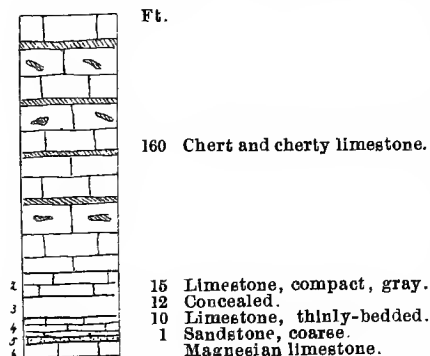


FIG. 83. Section in T. 21 N., 21 W.

township 21 N., 21 W., figure 83 was measured."

"At Powell's farm in section 28, township 23 N., 22 W., the section of figure 84 is exposed."

"The several strata of the marble beds have here about their usual thickness, but are not so prominent a feature of the topography."

"Good exposures of the Carboniferous rocks are rare along the narrow divides between the streams north of White river. Nearly everywhere, some few thin beds were seen protruding through the detrital chert; but only thin layers, and these occasionally."

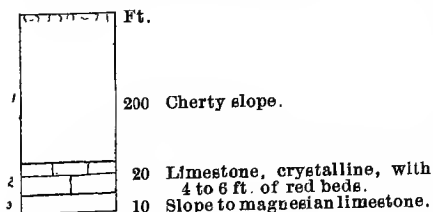


FIG. 84. Section at Powell's farm.

Over the interior and western portions of the Southwestern district, numerous sections have been measured and collections have been made and studied, for the purpose of correlating the beds exposed at different localities. Though the results are not up to expectations,

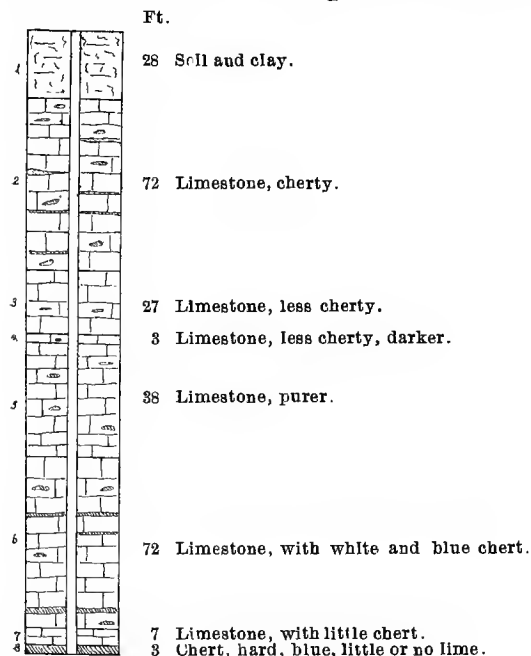


FIG. 85. Record of drill-hole on Orchard tract.

owing to inherent difficulties of the problems, still much valuable additional information has been acquired. These facts and results may be best presented and discussed in connection with four lines of observation traveled by the writer along Spring river, Shoal creek, Center creek and Turkey creek, respectively.

Spring River Sections and Notes.—The Spring river sections begin at the town of Aurora. Here we have the record of a deep drill-hole, put down on the Orchard tract, in

the NW. $\frac{1}{4}$, SW. $\frac{1}{4}$, section 7, township 26 N., 25 W., which is represented by figure 85.

The rocks exposed at or near the surface here are of the usual, coarsely crystalline limestone. Mr. Rowley visited this place, and, in the mine dumps, was able to identify the following species of fossils: *Streptorhynchus crenistria*, *Spirifera grimesi*, *Spiriferina* sp.?, *Cyrtina* sp.?, *Chonetes* (two undetermined species), *Productus flemingi*, *Productus* sp.?, *Terebratula burlingtonensis*, *Athyris incrassata*, *Eumetria verneuilliana*? *Zaphrentis centralis*, *Zaphrentis* sp.?, *Amplexus bicostatus*, *Bryozoa* (several undetermined forms), *Pentremites elongatus*, *Granatocrinus* sp.?, *Crania* sp.?, *Platyceras* sp.?, *Spirifera pseudo-lineata*? *Athyris* sp.?, *Rhynchonella* sp.? All of the above, except the *Eumetria* and *Streptorhynchus*, are common Burlington species.

Mr. Rowley notices that there is here, apparently, a mingling of both the Burlington and Keokuk fossils. This, he interprets as due to an intermingling of these forms in the limestone strata, or to the fact that the chert, in which the fossils were found, is a transition bed between the two formations.

Proceeding from Verona down Spring river, between three and four miles, bluffs are exposed about 40 ft. high, adjacent to the river. They are composed of alternate, very thin layers of chert and limestone, the former, if anything, in excess of the latter, at least in the lower 10 or 15 ft. This, thus, resembles the lower cherty beds of Mr. Marbn's sections, and also those later described near Grand falls on Shoal creek. Near this point, Mr. Rowley found in the overlying cherts *Amplexus bicostatus*, *Schizoblastus sayi*, *Spirifera grimesi*?, and a base of *Platycrinus*, all characteristic species of the Burlington limestone. Lower down, in the limestone, he found *Athyris hannibalensis*, *Orthis missouriensis*, *Zaphrentis* sp.?, *Productus* sp.?, and a *Granatocrinus sampsoni*?, which are all Chouteau species.

Thence down the river, for a couple of miles, exposures are scarce. After this, nearly to the mouth of Honey creek, outcrops of similar alternating layers of limestone and chert are frequent. The limestone contains a great quantity of small crinoid stems; the chert is in nodules and in characteristic wavy, lenticular layers. From this point, down the river, about five miles, no exposures were seen on the east side; the hill slopes are, however, very thickly covered with chert fragments.

At Big spring, under the east bluff of the river, about 3 miles west of Mt. Vernon, the section of figure 86 was measured by the writer.

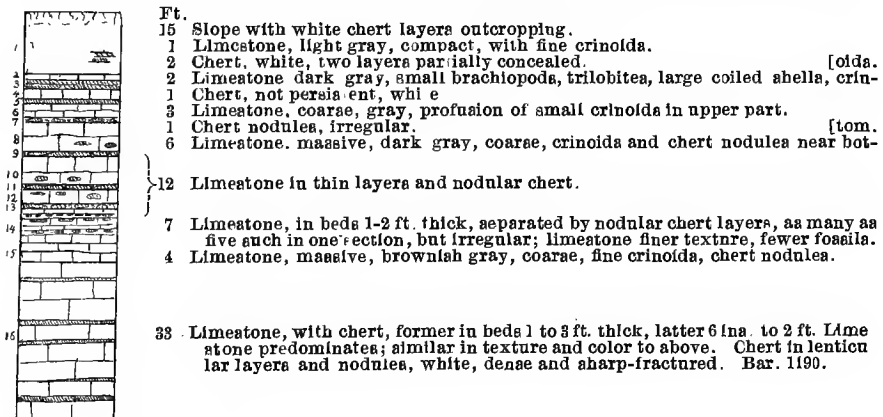


FIG. 87. Section near Mt. Vernon.

From the loose chert over the top of this bluff, Mr. Rowley obtained the following Burlington fossils: *Productus semireticulatus*, *Streptorhyncus crenistria*, *Spirifera grimesi*?, *Syringothyris hannibalensis*?, *Terebratula burlingtonensis*, *Zaphrentis centralis*, *Zaphrentis* sp.?. From the upper part of the bluff he obtained the following species, which indicate Kinderhook age: *Euomphalus latus*, *Athyris hannibalensis*, *Phillipsia* sp.?, *Zaphrentis* sp.?, *Terebratula*, sp.?, *Platyceras*, sp.?, *Productus flemingi*, Bryozoan coral, *Spirifera grimesi*?

Down the river from this point, a distance of three or four miles, exposures are not abundant. On the north side, in section 13, township 28 N., 28 W., is a bluff some 70 ft. high, exposing heavy beds of magnesian limestone, with chert in nodules and lenticular layers. Thence, for about three miles along the northern river bluff, limestone beds are almost continuously exposed; the lower layers are somewhat cherty, but chert was also found near the top, filled with fine crinoid stems, and the surface of the hills is thickly covered with sharp, angular fragments of white chert.

Over the next three miles, the river leaves the hills, which are of gentle slope with only an occasional limestone outcrop.

From Bower's mill to Adam's mill, a distance of about one and a-half miles, limestone exposures are again numerous. The lower 15 ft. of the sections contain a large amount of nodular chert; over this are massive beds of limestone, containing a profusion of crinoid stems, which beds are quarried at Bower's mill.

Down the river from Adam's mill, outcrops of limestone along the bluff are frequent and continuous for long distances; little chert is represented in the outcrops, though a considerable quantity is strewn over the surface.

From a point about two miles east of the bridge over the river above the mouth of White Oak creek, down to that bridge, is a continuous bluff. Limestone is here exposed to a height of about 75 ft. in

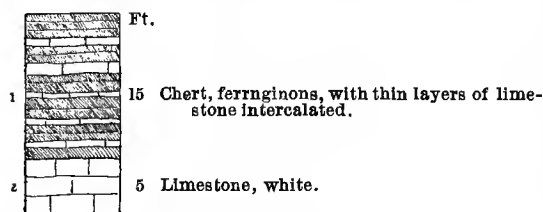


FIG. 87. Section near Blg spring.

the bluff, partly concealed by the talus.

horizontal beds, both massive and thinly bedded; very little chert was observed, though occasional outcrops were seen under the upper massive limestone, about half-way up

At the Big spring, on the left-hand side, south of this bridge, figure 87 was measured.

The hill-sides about this spring are covered with fragments of dense, white, chert, while porous, red chert is found on the hill-tops.

Thence, down the river, along the southern bluff, exposures of limestone are frequent, and the tops of the hills are covered with fragments of the porous chert.

About four miles above Carthage, figure 88 was measured.

On the eastern edge of Carthage, in the road just east of the railway crossing, figure 89 is exposed.

Fragments of the chert (No. 1) cap the hills between this and the preceding section, and they are, moreover, found over nearly all of the hill-tops about Carthage.

A short distance west of this, in the SW. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 3, near the hill-top, a drill-hole was put down 2005 ft. Samples from this, in possession of Mr. D. R. Goucher and Maj. J. W. Sherburne, were kindly furnished Mr. Robertson for examination. From this the section of figure 90 was prepared.

A review of these sections down Spring river indicates that higher beds are

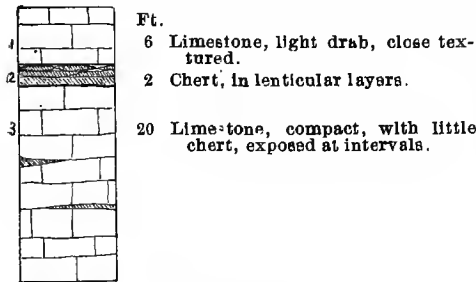


FIG. 88. Section near Carthage.

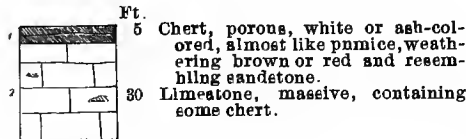


FIG. 89. Section east of Carthage.

Ft. LOWER CARBONIFEROUS.

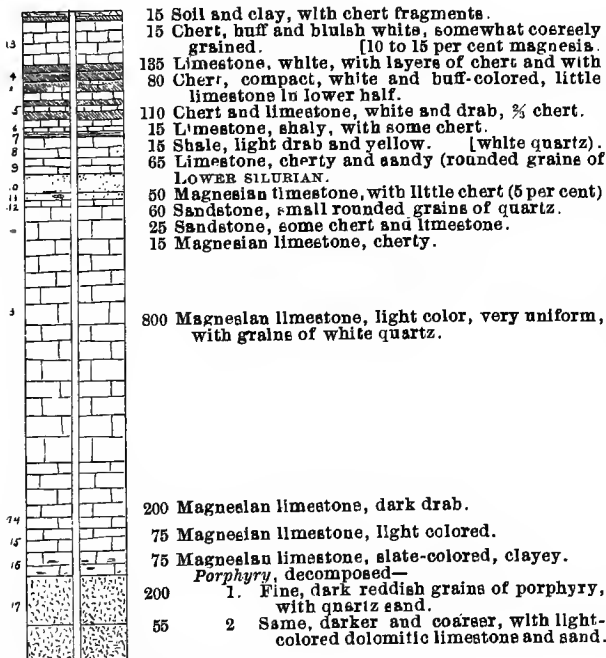


FIG. 90. Section of Carthage drill-hole.

reached as one proceeds westward. The lower, cherty layers, exposed below Verona, seem to sink lower, and the upper massive layers of limestone constitute the mass of the exposures. Above this, the porous red chert comes in.

In the railway cuts and quarries at Carthage, the heavy massive beds are well exposed. These were specially studied by Prof. Rowley, who reports as follows:

"Just west of the Frisco depot, there are 40 ft. of a light leaden-gray limestone exposed in a quarry. An examination of the weathered surface, from the railway to the top of the bluff, gave no crinoids, though the stems were abundant. A reddish cherty clay caps the limestone. The chert is noticeably persistent in heavy bands. At the quarry of the Carthage Quarry and Construction company, similar characteristics prevail, and the limestone is seen to contain little chert except in bands. The fossils collected at Carthage were *Spirifera keokuk*, *S. pseudolineata*, *S. neglecta*?, *S. sp.*?, *Orthis sp.*?, *O. swallowi*?, *Streptorhynchus robusta*, *S. crenistria*?, *Productus semireticulatus*?, *P. punctatus*, *P. sp.*?, *Terebratula*, *sp.*?, *Eumetria verneuiliana*, *Archimedes owenana*, *Myalina sp.*?, *Zaphrentis centralis*?, and a fish-tooth. Several of the above fossils were presented by Mr. W. H. Crabtree. The outcrops here at Carthage are Keokuk limestones."

Center Creek Sections.—Beginning at Sarcovie, there are, on both sides of the creek, bluffs and quarries of the thickly bedded limestone, containing chert in nodules and thin layers. Limestone of similar character is exposed farther down the creek, east of Reed's. About due south of Carthage, some heavy beds of chert were seen close to the water's edge. Thence, down the stream, there are few prominent outcrops. About a quarter of a mile east of the Missouri Pacific railway bridge, are exposures consisting of alternate layers of limestone and chert, close to the water's edge. These also occur west of the bridge.

At the Moody quarry, about a mile farther west, some 40 ft. of limestone is exposed, containing little or no chert. Crevices, well exposed here, traverse the face of the quarry, and are seen to be filled in places with a solid breccia cemented by lime, and elsewhere with loose clay. Thence westward, for some distance, are only occasional exposures.

Just west of the pump-house, north of Carterville, are bluffs of limestone, 80 to 100 ft. high; the rock is thickly bedded, and, though flaky, does not contain much chert. This is exposed almost continu-

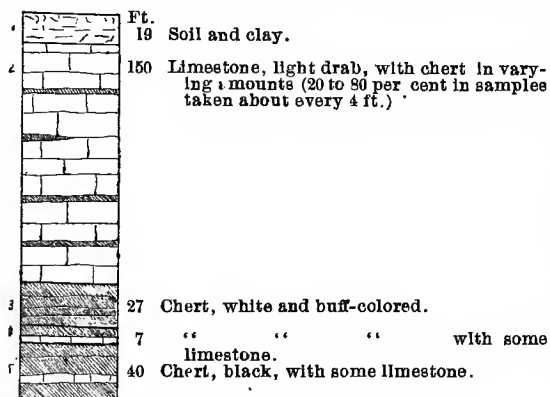


Fig. 91. Section of drill-hole on the Motley land.

ously westward to the Frisco railway and several quarries are opened on it. As illustrating the section of rocks at greater depths here, we add in figure 91 the record of a drill-hole sunk on the Motley lands, in Carterville, in section 20. The samples were examined by Mr. Robertson.

For about a mile beyond the Frisco railway bridge, limestone with interbedded and lenticular chert appears in the bluffs. Then, after a gap of another mile, exposures come in again. Bluffs about 20 ft. high are to be seen on both sides of the bridge of the Girard branch of the Frisco railway. Within half a mile west of this bridge, a large mass of gnarled chert, like that of Grand falls, crops out, though somewhat intermixed with limestone. West of this again are occasional outcrops of limestone with thin layers, and nodules of chert. The section here is illustrated by figure 92, from measurements made in the bluffs about half a mile below the high wagon bridge, in section 13.

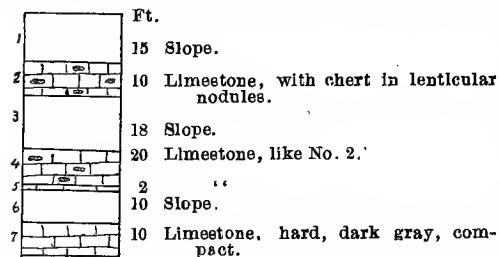


Fig. 92. Section near Lehigh wagon bridge.

Turkey Creek Sections.--Along the upper portion of Turkey creek, as far west as Tuckahoe, there are few outcrops, and such as exist consist of only a few feet of limestone; there are no exposures from which long, continuous sections can be constructed.

At the Henry Tucher mine, just east of the Frisco railway, on the north side of Turkey creek, a shaft and deep drill-hole were put down to a depth of 250 ft. Figure 93 is prepared from the records. The top of the shaft is only a few feet above the creek bottom.

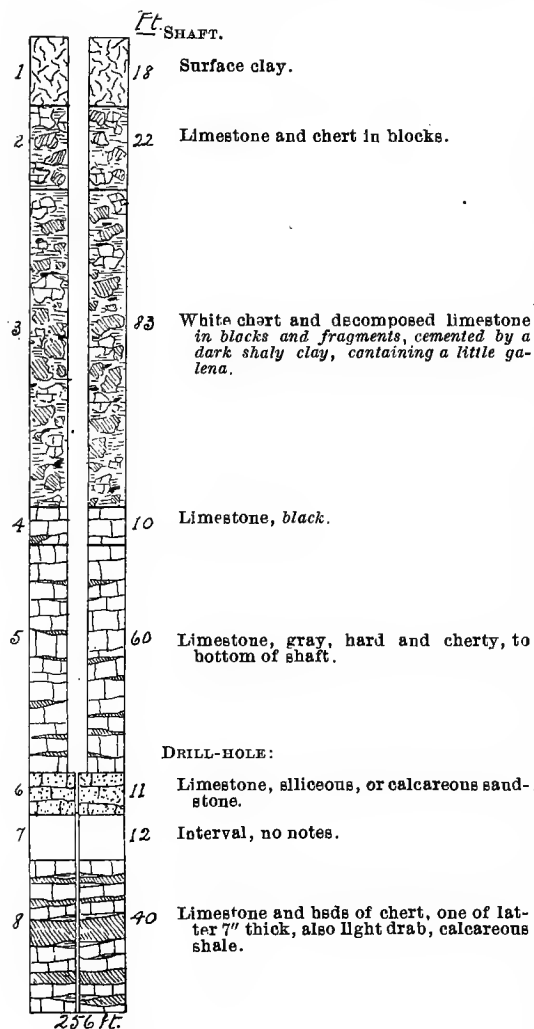


Fig. 93. Section of Henry Tucher shaft.

side of the creek, below the Frisco railway, at the mouth of Possum hollow, the section of figure 94 was measured by the writer.

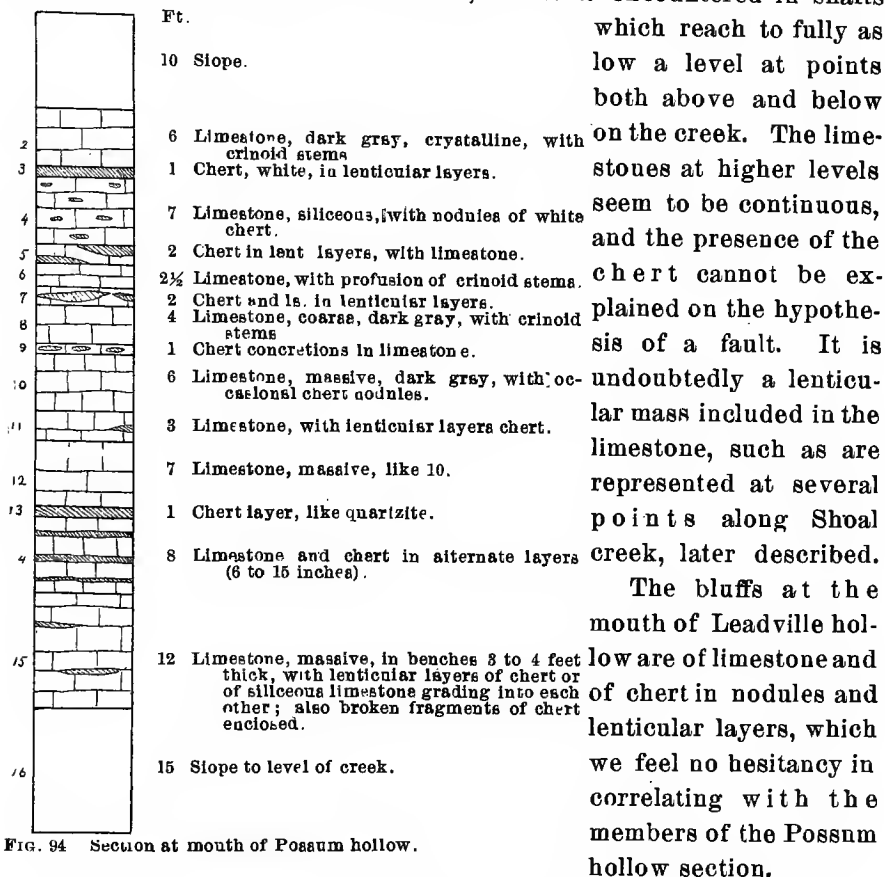
The rocks of this section form a continuous bluff down the creek to the mouth of Leadville hollow. At the latter point, in the creek, is an outcrop of chert, which rises to a height of 10 ft. or so above the bed. This is a white rock, gnarled and knotted and very tough,

Close to this, a shallow shaft was sunk, in which oolitic limestone was encountered near the surface. From this an interesting series of fossils were found and were examined by Mr. Rowley, who reports as follows:

"On Turkey creek, one and a half miles northwest of Joplin, in the dark blue shaly limestone thrown out at a shaft, were found *Synocladia rectistyla*, *Chætetes?* sp.?, *Archimedes* sp.?, *Spirifera setigera*, a *Chonetes*, an undetermined Bryozoan, and bases of *Agassizocrinus*, a genus not found below the Kaskaskia or Chester. The *Archimedes* is a Chester species described and figured by Ulrich." Prof. Rowley was at the time of the opinion that no doubt existed as to the Kaskaskia or Chester age of the rocks in which these fossils were found.

In the bluff on the south

but not brecciated; stratification planes are not traceable. Such chert was not observed in sections, nor is it encountered in shafts



which reach to fully as low a level at points both above and below on the creek. The limestones at higher levels seem to be continuous, and the presence of the chert cannot be explained on the hypothesis of a fault. It is undoubtedly a lenticular mass included in the limestone, such as are represented at several points along Shoal creek, later described.

The bluffs at the mouth of Leadville hollow are of limestone and of chert in nodules and lenticular layers, which we feel no hesitancy in correlating with the members of the Possum hollow section.

Thence, down the creek a distance of some two miles, bluffs of the same rocks were seen at a number of points.

At the mouth of East hollow, just above the Gulf railway, coarse, crystalline limestone, fully 15 ft. thick, is exposed about 50 ft. above the creek; it contains chert in nodules and lenticular layers. Some disturbance is shown here by a dip of the strata toward a small ravine, but this is entirely local.

At Cave spring, near the western line of section 25, south of Belleville, figure 95 was measured.

Thence, down Turkey creek, a distance of two miles, to near its mouth, no further exposures of limestone were observed, though the

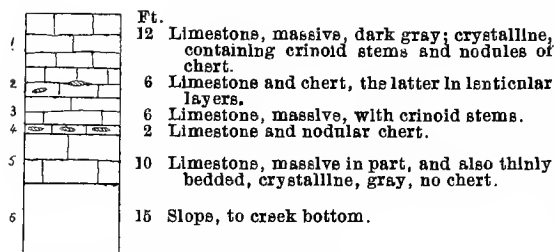


FIG. 95. Section at Cave Spring.

50 ft. above the river bottom; over this no limestone fragments are found, but blocks and fragments of chert of somewhat open texture are abundant. In a small quarry, about 20 ft. above the creek, alternate layers of limestone and chert are exposed, aggregating about 6 ft., the layers being a foot or less thick. In cross-section, these layers are seen to be of lenticular shape, such that, in one portion of the exposure, the limestone is about in equal proportion to the chert, while, within 10 ft. of this, the chert largely predominates.

In the bluff, just north of the mouth of Turkey creek, the same limestone beds are exposed at intervals to a height of about 50 ft. above the bottoms, and chert fragments similarly cover the surface to the top of the hill.

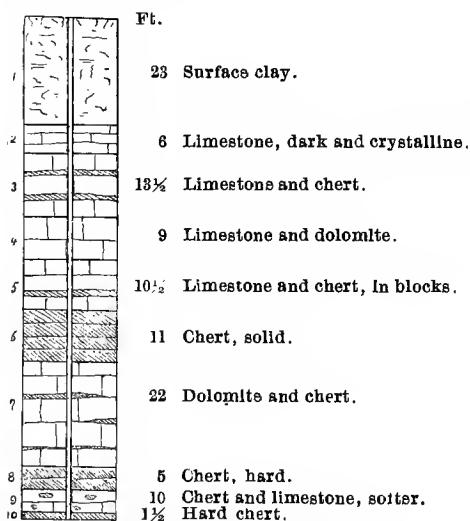


FIG. 96. Record of drill-hole on Western Zinc Co.'s land, in SW. of SE ¼ Sec. 11, T. 27 N., R. 33 W. Near hill-top.

hills are liberally covered with chert.

On the east bank of Spring river, about a quarter of a mile below the mouth of Turkey creek, limestone is exposed to a height of fully

Joplin and Vicinity.—In and about Joplin, and at other points south of the city, a large number of drill-holes have been put down, which throw much light upon the local stratigraphy. Of these we select a few which will show the general succession of rocks from the surface, to depths of nearly 1400 ft. They are given in such order that they make a nearly complete column. Of all, excepting the first, samples were kindly furnished by Mr. Perry Crossman, the driller, and were examined by the writer or Mr. Robertson, and carefully tested with acid.

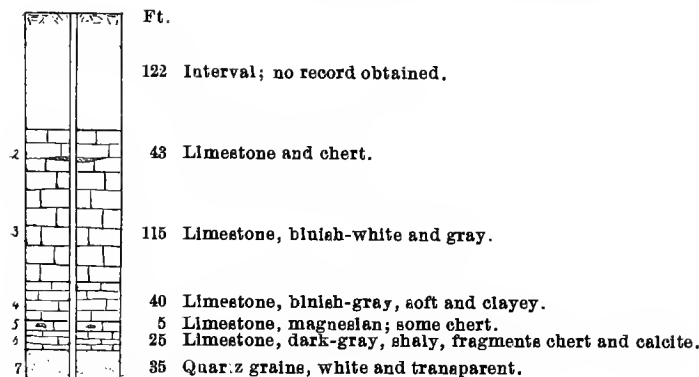


FIG. 97. Record of drill-hole on Lloyd and Ginn's land, NW. of NE $\frac{1}{4}$ section 14, township 33 N, 27 W.

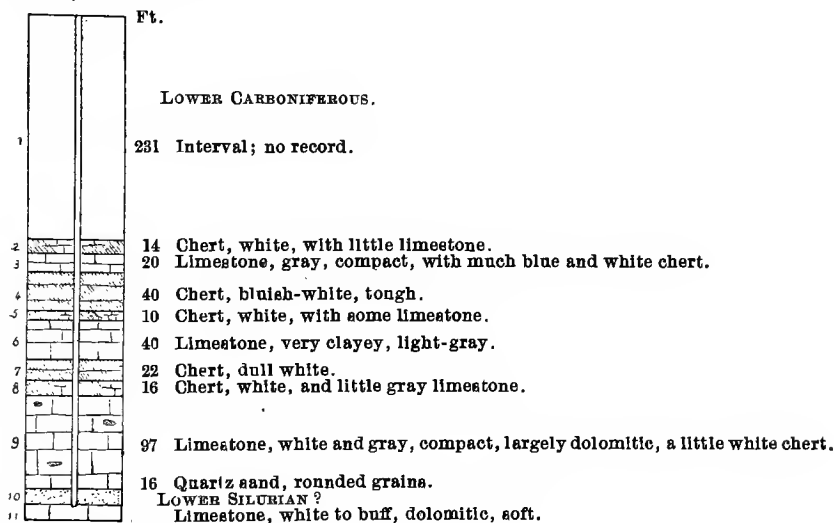


FIG. 98. Record of drill-hole at brewery near St. L. & S. F. R'y depot.

Shoal Creek Sections.—Beginning at Ritchie, on Shoal creek, above Granby, large masses and fragments of chert over the hill-slopes north of the town indicate that thick beds of that rock exist there; outcrops of limestone are, however, also seen.

About a half a mile west of this point, along the railway, is a bluff of limestone about 100 ft. high, in which massive layers are seen overlying thinner beds, the latter containing much chert. A half-mile farther west, beyond the bridge, are other bluffs of similar limestone, with a granular chert beneath, at the railway level.

About three miles farther west, at the 300-mile post, a point of the hill comes down to the railway on the south side, in which is exposed a bluff of chert about 15 ft. high. This rock is of the gnarled, massive kind abundantly exposed lower down about Grand falls. Opposite this

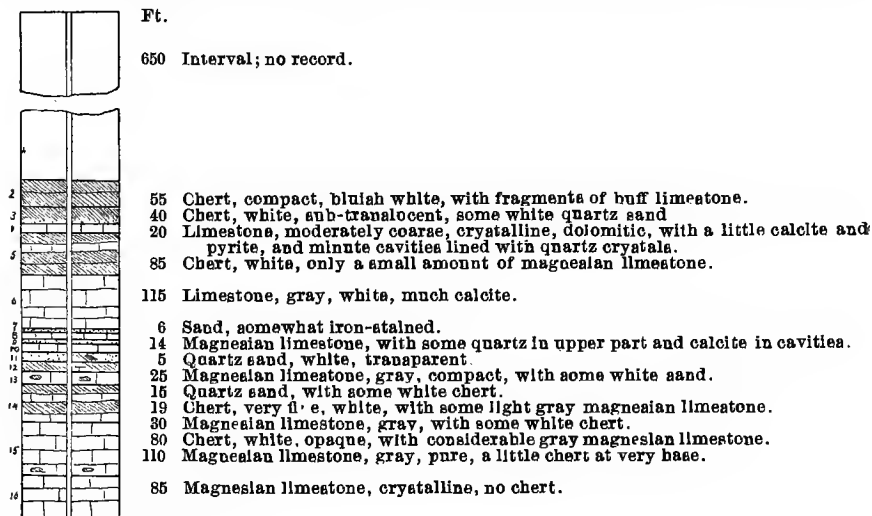


FIG. 99. Record of drill-hole at Ice plant, Joplin.

point, regularly bedded limestones were seen in the bluffs of the creek and no extension of this massive chert can be recognized there.

About a half a mile farther east, limestone is abundantly exposed, and at Granby mill are bluffs reaching 30 to 40 ft. above the creek. Beyond this are rounded hill-slopes, covered with small fragments of chert, such as might result from the decomposition of limestone beds containing the usual nodules or lenses of chert.

Succeeding this, from a point about a mile and a quarter above the Granby depot, for a distance of a quarter of a mile westward, there is an almost continuous exposure of chert, along the southern bluff of the creek. This chert exhibits no bedding, but is massive, gnarled and

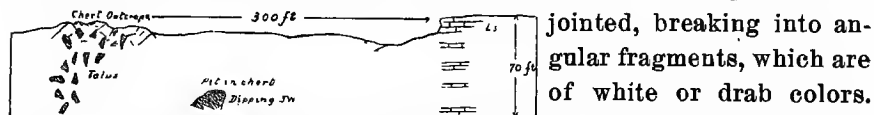


FIG. 100. Illustrating non-persistence of chert near Granby. At the eastern end of this exposure, a shaft penetrated a mass of white chert fragments cemented by dark, secondary chert, such as is common in the mines. This breccia is, however, different from the main chert mass. At a point about a mile above the depot, this chert ceases to form the hill bluff somewhat

abruptly, as is illustrated in the preceding figure 100. A quarter of a mile farther, figure 101 was measured.

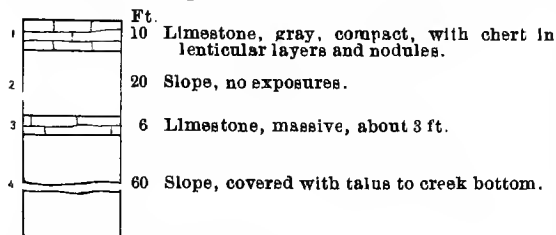


FIG. 101. Section near Granby.

Of these, one numbered 4 is located just south of the middle of the east line of the NE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 12. The following figure 102 is constructed from examinations by the writer of drill specimens kindly furnished by the superintendent, Mr. Kingston.

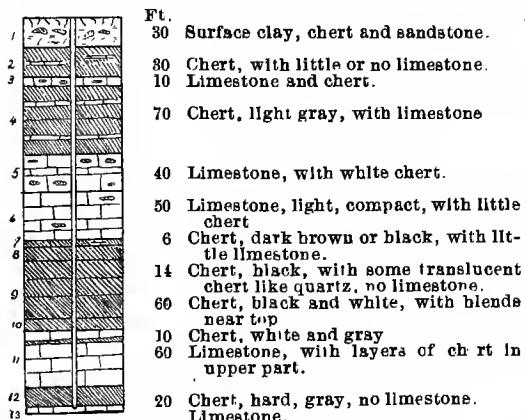


FIG. 102 Record of drill-hole No. 4, at Granby.

and a *Phillipsia* sp.? Mr. Rowley characterizes this as a strange mingling of Lower Carboniferous forms.

Continuing down Shoal creek, from Granby depot, at a point about three miles west of Granby, in a hollow about a mile south of the creek, a bluff of gnarled, shattered looking chert, like the Grand Falls rock, rises from the level of the branch to a height of about 50 feet, while in adjoining hills limestone bluffs are exposed at the same altitude. Perhaps a mile from here, and a little farther west, massive beds of limestone are exposed in the bluff of the creek, rising to a height of 50 feet, with only a little chert, in nodules and lenticular layers. The creek here is about 40 feet below the base of the chert outcrop last described.

Between this section and the depot, the limestone seems to be interrupted by two or more "chert breaks," and one pocket of coal shales.

At Granby, a number of drill-holes have been put

down. From the examination of Mr. Kingston's collections, made about the Granby mines, Mr. Rowley identifies the following species: *Spirifer hannahensis*, *Productus* sp.?, *Loxonema* sp.?, (*delphicola*), *Platyceras* sp.?, *Zaphrentis centralis*, *Amplexus bicostatus*, *Zaphrentis* sp.?, *Actinocrinus* sp.?, *Forbesiocrinus*? *wortheni*?, *Pentremites godeni*,

About a mile or two above the Valley mills, a similar bluff of limestone is exposed.

At Neosho, are fine bluffs of this limestone. At the large spring west of the hotel, about 30 ft. of heavily bedded limestone is seen to overlie about 10 ft. of chert and limestone in thin, lenticular layers. In these lower chert beds, Mr. Rowley found specimens of *Spirifera*, *Rhynchonella*, *Terebratula*, *Fenistella*, *Productus* (like a small species found in the lower Burlington at Louisiana), *Phillipsia* (the same species found west of Mt. Vernon) and crinoid stems. Mr. Rowley suggests that these chert layers may be Kinderhook, though the fossils are not distinctive. It is hardly possible, however, that beds so low in a series should be at the surface here.

Northeast of the town are a number of quarries in the hill-sides. The limestone is dark or bluish gray, with an abundance of crinoid stems and comparatively little chert. Cherts near the top of the hill gave to Mr. Rowley: *Streptorhynchus crenistria*, *Productus Flemingi*, *Rhynchonella* sp.? *Platycrinus* sp.? *Zaphrentis centralis*, *Amplexus bicostatus*. The limestone here generally yields the first-named fossil, *Spirifera grimesi*, *S. hannibalensis* the *Rhynchonella* and *Zaphrentis*. About the middle of the hill-slope, in the face of an old quarry, he found joints of *Platycrinus* stems, a base of the same genus and broken parts of *Agaricocrinus* and *Doryerimus*, identically with the species of a similar bed in Springfield. The entire exposuro here, Mr. Rowley concludes must be Burlington.

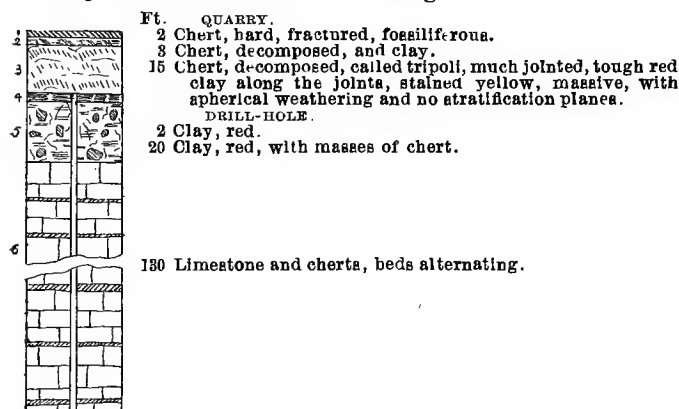


FIG 103 Section at Tripoli quarry.

The same rocks are exposed west of Neosho, and good opportunities for sections are presented along the railway. Examinations have, however, been made so far only at Seneca.

About a mile north of the town are what are known as the Tripoli works and quarry. Here figure 103 was measured and supplemented by the results of a drill-hole, given by the superintendent.

Just north of the town of Seneca, limestone outcrops along the slope of the hill. The color is bluish gray, and it is cherty. In this, Professor Rowley found *Productus semireticulatus* ? and large *Platycrinus* stems, such as had been observed at Springfield and Neosho. One and one-half miles northeast of the town, at Hueber's mines, up the little runs and on the dumps, the following species were found : *Productus Flemingii*, P. sp. ? (common in the lower Burlington limestone at Louisiana, Mo.), P. sp. ?, *Orthis* sp. ?, *Spirifera* sp. ?, *Rhynchonella* sp. ?, *Spiriferina solidirostris* ?, *Terebratula* sp. ?, (in Burlington limestone at Louisiana, Mo.) *Retzia* sp. ? (common in lower Burlington limestone at Louisiana, Mo.) *Spirifera lineata* ?, *Streptorhynchus crenistria*, *Amplexus bicostatus*, *Zaphrentis centralis*, *Aulopora* sp. ?, *Platyceras* sp. ?, *Platycrinus* base, *Allorisma* sp. ? (found in Lower Burlington limestone at Louisiana, Mo.), *Fenestella*, two or three undetermined species.

Proceeding northward from Neosho down Shoal creek, a bluff was examined on Cedar creek, not far above its mouth. This is about 50 ft. high, and consists of limestone with interbedded lenticular layers of chert. No massive beds of chert were seen.

About two miles farther north, on the west side of the creek, where the Joplin road crosses it, is a bluff of which figure 104 is a section.

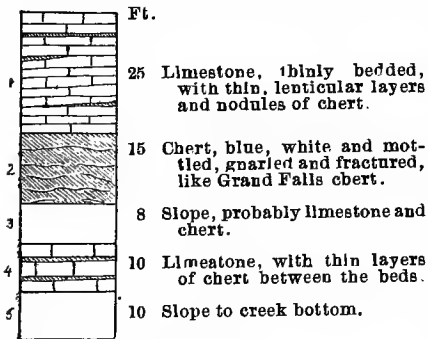


FIG. 104. Section on Shoal creek, near Joplin road.

The massive chert bed can be traced some distance northward from this point, but about a quarter of a mile down the stream it is not exposed, and is apparently absent. Here the hill is about 100 feet high, and limestone crops out at intervals from the top to the bottom. The bed of massive chert appears to terminate practically at a small ravine just south of the high limestone hill, though on the northern side of the ravine are a few outcrops of, apparently, a much attenuated extension of this chert bed.

About a half mile farther north, on the eastern side of the valley, is the Rawlingston spring, which flows from under a limestone bluff fully 50 feet high.

Some two miles farther north, also on the eastern side of the valley, is another large spring and bluff, about a mile south of Thurman. Of this, figure 105 was measured.

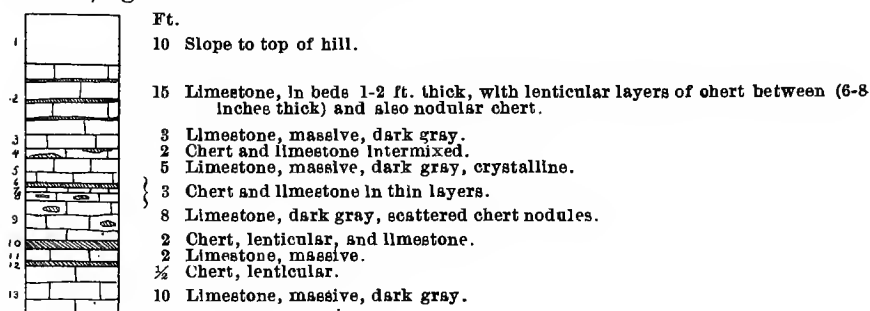


FIG. 105 Section near Thurman.

The bottom of this section is only a few feet above the creek valley.

From Thurman, down the river, limestone is exposed continuously; it is of dark gray color, crystalline and coarse, with lenticular chert layers between the beds. About a mile from Thurman is a quarry exposing such rock to a height of 50 feet or more above the river. The limestone beds are one to three feet thick, and the chert layers about 6 inches. A joint, or slight fault, was observed here, along which the limestone was much brecciated, and in places was filled with chert fragments, held firmly in a cement of secondary limestone. The beds of this quarry dip 5 to 10° E., but recurve up again across the hollow about 200 feet east.

Westward from this quarry, the limestone is traceable in the upper part of the hill. Within about a quarter of a mile, however, a thick mass of chert appears suddenly, and is traceable a distance of about 400 feet to Bently's ford, where it stands out a prominent bluff. This is the familiar, rough, massive chert, in part brecciated, the fragments being cemented by a black secondary chert. Some galena and calcite were also found in it in places. The limestone of the upper hill-slope extends continuously over this chert.

A few hundred yards west of this, limestone is again abundantly exposed along the lower slopes of the hills, and outcrops to the top are sufficiently abundant to preclude the possibility of the heavy chert mass existing here.

Opposite this, on the southern side of the creek, limestone also

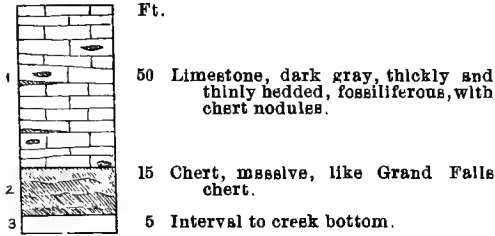


FIG. 106. Section near Redding's mill.

but, about a quarter of a mile east of Redding's mill, figure 106 was exposed.

The chert makes its appearance with characteristic abruptness, while the overlying

limestone beds are continuous with those last referred to. In fact, limestone crops out immediately east of the chert, below the level of the top of the latter. West of this section, however, the chert can be traced continuously to Redding's mill, and beyond to Grand falls. At the former point the chert is exposed to a thickness of 25 ft., reaching to the bed of the creek. It is seen to be traversed by jointage planes, running in N.-S. and N. 60° W. directions. It is mostly white on fresh fracture, and is brecciated in part. A drill-hole put down here passed through the rocks shown in figure 107.

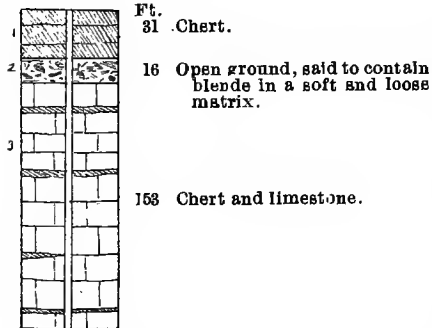


FIG. 107. Section of drill-hole near Grand falls.

The high hill on the south side of the creek, just below the mill, appears to be made up largely of chert. The presence of these hard rocks explains the gorge in which the creek flows, nearly down to Grand falls.

At Grand falls, the chert is exposed on both banks of the creek, about 30 ft. high, and over a bluff of this rock the creek falls. It is a very dense, hard chert, in massive layers 6 or more feet thick; it has a gnarled and knotted structure, producing an uneven surface; the fracture is distinctly conchoidal.

From this point down the creek half a mile, the sketched cross-section of figure 108 is constructed.

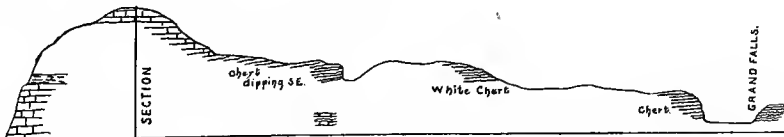


FIG. 108. Cross-section at Grand falls, showing non-persistence of limestones and chert.

From the summit to the creek, the section is shown in figure 109.

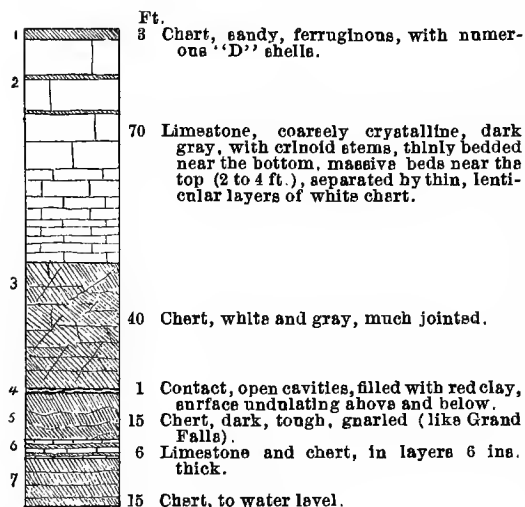


FIG. 109. Section at Grand falls.

At the western end of the cross section A-B, the massive Grand Falls chert is not represented; but, exactly in its position, is a stratum composed of thin layers or lenses of chert and limestone; these lenses are very intimately mixed, and their contacts are irregular, somewhat as is illustrated in figure 110. The appearance of the whole bluff is that of a mass of chert, but the limestone is easily separated on close inspection.

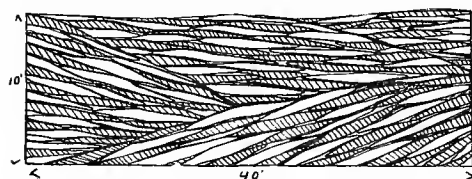


FIG. 110. Illustrating occurrence of chert and limestone near Grand Falls.

This stratum, and the overlying, regularly bedded limestone, is traceable westward continuously. In the bluffs on the south side, however, the massive Grand Falls chert is also continuous, in a ledge about 25 ft. above the creek. Under this, however, limestone occurs. The bluff composed of this chert is nearly unbroken for a mile or so farther west. On the north bank of the creek, at the spring ford, it is exposed in bluffs on both sides. At the spring, alternations of limestone and chert are exposed in the road, and these are traceable northward, and seen to pass under the massive Grand Falls chert.

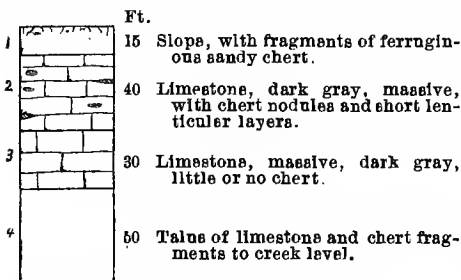


FIG. 111. Section at the Seneca road ford.

At the Seneca road ford, about a mile farther west, a section of the north bluff was measured, and is shown in figure 111.

The Grand Falls chert does not appear in this section, and probably does not extend this far down the creek. That it is

not hidden in the talus is proven by the fact that about a quarter of a mile below this, thinly bedded limestone containing nodules and thin layers of the white chert is exposed as low down as the bank of the creek.

Just above the mouth of Jackson's hollow, figure 112 was seen.

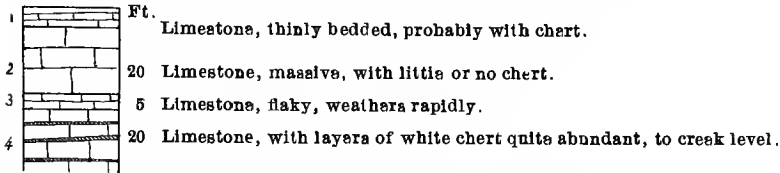


FIG. 112. Section at mouth of Jackson's hollow.

Just above the mouth of Rocky hollow, figure 113 was measured in a prominent bluff on the north side.

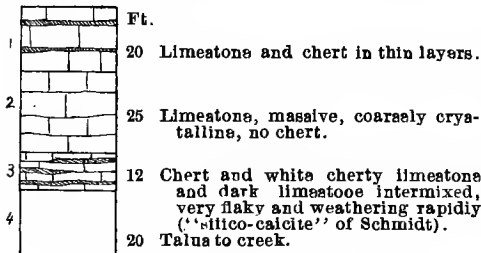


FIG. 113. Section near mouth of Rocky hollow.

About a half mile west of this, on the state line, the cherty limestone (No. 3) is well exposed. Thence, along the north side, down to the pump-house, south of Galena, the same stratum crops out frequently. Fine bluffs occur about a quarter of a mile above the pump-

house, with the cherty limestone reaching 25 feet above the creek bottom, capped by the massive limestone.

Beyond this, on the south side of the creek, are similar bluffs 75 feet high.

About half a mile down the creek, a bluff of chert 20 feet high rises from the water's edge. Again, about half a mile farther, at the point of a sharp loop on the north side of the creek, is a bluff of chert like the Grand Falls, 15 feet high. A little below this, however, just above the wagon-bridge some 20 feet of cherty limestone are exposed, rising to about 20 feet above the water-level, and capped by massive and tabular limestone.

These observations along Shoal creek, especially from Thurman down, show, beyond reasonable doubt, that the massive cherts of Grand falls and other localities do not form a continuous stratum, but are simply highly silicified portions of the lower cherty layers. The continuity of the bluffs, with the correspondence in other respects between the different sections, shows further that no considerable faults traverse the country here, and, therefore, the abrupt cessation of

the beds of massive chert, or other phenomena, cannot be attributed to that cause.

The town of Galena is between two and three miles north of the last section, at an elevation of some 60 or 80 ft. above the creek. In the limestone outcrops in the northern part of town, along Shoal creek, Prof. Rowley identified the following species: *Spirifera grimesi*, *S. pseudolineata*, *Orthis swallowi*, a fine *Zaphrentis* (probably *centralis*), *Athyris incrussata*, *Platycrinus* and other crinoid columns; also two or three poor specimens of *Batocrinus*, like the form common in the Burlington limestone of Springfield. In the cherts about the dumps were found *Platycrinus* sp.?, *Amplexus bicostatus*, *Streptorhyncus crenistria*?, *Actinocrinus*? sp.?, *Retzia* sp.?, (like a Lower Burlington species at Louisiana, Mo., but a little larger), *Productus punctatus*, *Productus* sp.?, (like a Lower Burlington species), and a Bryozoan gen.?

At one of the mine dumps, in shaly limestone, said to have come from 120 ft. depth, were found quite abundant crinoid columns, a fragment of a *Batocrinus* sp.?, *Agaricocrinus* sp.?, (badly crushed), a small weathered *Zaphrentis* sp.?, a small *Orthoceras* sp.?, a fragment of a *Spirifera* sp.?, and a Bryozoan.

In Mr. D. H. Swaney's collection, made from the chert of the mine dumps, were seen: *Productus hemingi*, *Chonetes* sp.?, *Spirifera grimesi*, *S. pseudolineata*, *Euomphalus*? sp.?, *Loxonema* (like *dephicola*), *Pleurotomaria*? sp.?, (large), *Zaphrentis centralis* and *Amplexus bicostatus*, all Burlington species.

Contacts—That the Lower Carboniferous strata rest unconformably upon the magnesian limestones has already appeared, and because of this the lowermost beds are not always present. It may thus happen that the Burlington rests directly upon the Silurian, where the latter occurs as a ridge of the old surface; while immediately adjoining, in some depression, a full section of the Kinderhook beds may appear. But with due allowance for this, the data so far obtained and studied, though scant in conclusive facts, suggest that the lower sandstones and chert of the Kinderhook stage do not extend into the interior; the formation may be present there; but, if so, it appears to be of different composition.

After the Lower Carboniferous epoch, there followed, undoubtedly, a long erosion period, and the surface became denuded and trenched. Upon this surface the lower Coal Measure or Pennsylvanian rocks were laid down unconformably, as will next appear.

THE COAL MEASURES.

The Coal Measures, like the Lower Carboniferous, occur principally in the Southwestern district. The Southeastern is destitute of rocks of this epoch.

In the Central district, only a narrow strip along the western edge and a few patches or pockets of shale and coal occur. The latter are similar to those to be described in the Southwestern district, but are not associated with large bodies of ore. They are of special interest here because of the great thickness of the coal, which sometimes reaches as much as 70 ft. Such coal pockets are sometimes of greater vertical than horizontal dimensions. The beds of these pockets are often undisturbed, though dipping toward the center. They occur sometimes surrounded by Lower Carboniferous rocks, sometimes by Silurian, in either case proving unconformity.

The main Coal Measure area of the Southwestern district, as shown on the map, is in the extreme northwestern portion, where the margin of the Kansas and western Missouri coal-field is represented. Of this we shall have little to say here, as it is not of direct or special importance to the mining district. Beyond this main area, however, in Jasper and Newton counties, are numerous outliers or patches of Coal Measure rocks, too small to even locate on a map of the scale used. These patches are relatively often of great thickness, when compared with other dimensions—frequently 50 ft. or more. They are composed largely of drab shale, sometimes also of sandstone (generally micaceous) and of calcareous beds. They generally occupy what were originally depressions or “pockets” of approximate circular outline in the Lower Carboniferous limestone, which were probably great sink-holes. The strata are sometimes horizontal and undisturbed, and are sometimes highly tilted or broken. They often include coal beds, and south of Joplin and about Webb City many tons have been mined for local sale. A number of these occurrences will be described later in connection with the mines, and need not receive further notice here.

Within these same counties, fragments and occasional outcrops of ferruginous and micaceous sandstones cap the mounds and hill-tops. This rock is particularly abundant about Carl Junction; it is also found about Joplin and elsewhere in the county. Topographically these sandstones are above the shales etc., of the coal pockets; but they are not certainly geologically above them.

GRAYDON SPRINGS SANDSTONE AND CONGLOMERATE.

Farther east, in Lawrence, Greene and Dade counties, is another series of patches of Coal Measure rocks. These have been mapped in large part, but more detailed work is necessary before their outlines can be fully shown. Those of Greene county were mapped by Prof. Shepard. These patches are of greater size than those of Jasper county, but they are still small and comparatively isolated. Lithologically they consist of conglomerates, sandstones, shales, and a little coal in places.

A small outcrop of the conglomerate is illustrated in the opposite plate. It is made up almost entirely of chert pebbles. These are well rounded and water-worn. They vary in size from one inch to nearly a foot in diameter. The pebbles are sometimes loose, so that the material can be dug with pick and shovel; sometimes they are held firmly in a matrix of ferruginous sandstone. This rock often occupies depressions or channels in the Lower Carboniferous rocks, as if washed into pre-existing hollows along the old shore line. These are sometimes 50 ft. deep. It also occurs along the extreme eastern border of the formation, capping ridges which have been formed by denudation since the deposition of the rocks.

The sandstone is generally coarsely grained and friable, ferruginous, of red or yellow colors, and somewhat micaceous. It seems usually to overlie the conglomerate and to cover wider areas. From the profusion of remnants in the form of isolated patches, we judge that it probably spread in the past over the entire district. Because of the abundance of excellent exposures of these rocks at Graydon springs, we apply the name of Graydon Spring sandstone and conglomerate, a name originally proposed by Dr. W. P. Jenney.

The shales have not a very clearly defined relation to the conglomerate and sandstone. They appear, however, to be above the latter, and, according to Prof. Shepard, the shales fill depressions in the conglomerate.

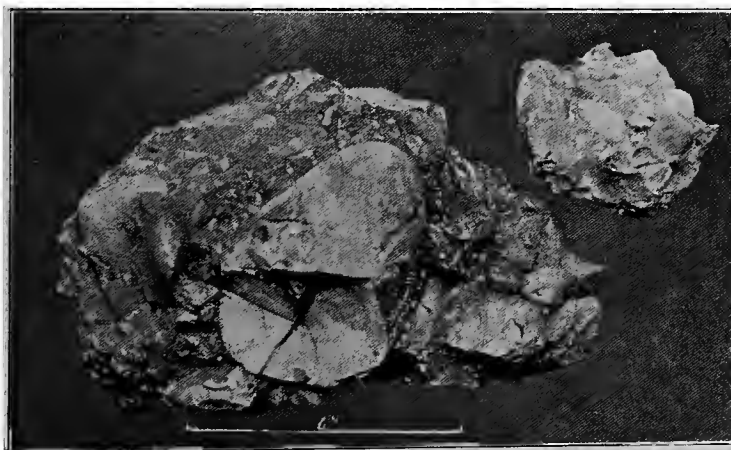
The distribution of these Coal Measure rocks is quite well shown on the district map. A brief description of the exposures at the different localities will be of interest.

The westernmost is that of the Corry mine, in northeastern Dade county. Here, along Turnback creek, south of the mines, the micaceous sandstone and chert conglomerate are exposed in great thickness

FIG. 1.



FIG. 2.



COAL MEASURE CONGLOMERATE, AT BILLINGS.

FIG. 1. RAILWAY CUT ON THE ST. L. & S. P. RY., AT BILLINGS.
From photograph by G. E. Ladd.

FIG. 2. CONSOLIDATED FRAGMENTS OF THE CONGLOMERATE.

FIG. 1.

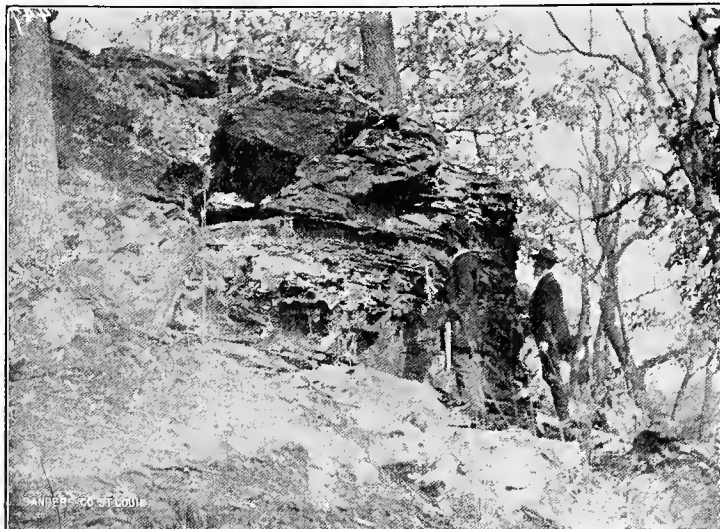
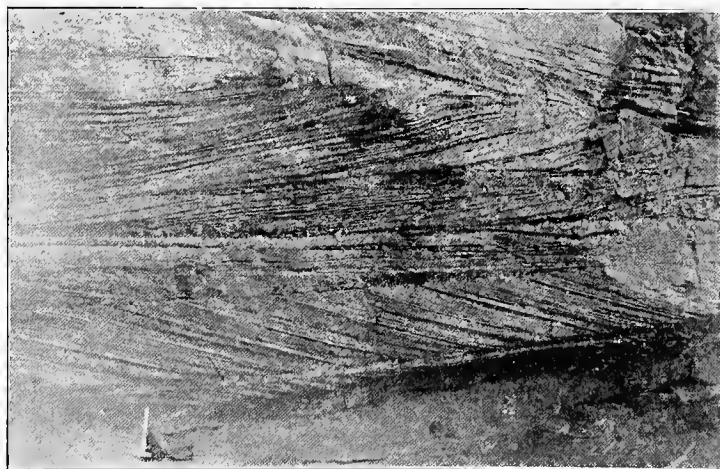


FIG. 2.



GRAYDON SPRINGS SANDSTONE.

FIG. 1. BLUFF OF VESICULAR SANDSTONE, ORAYDON SPRINGS.
From photograph by E. M. Shepard.

FIG. 2. CROSS-BEDDED SANDSTONE, MONEGAW SPRINGS.
From photograph by A. E. Woodward.

and are traceable thence to the mines, though the limestone country-rock intervenes at places. At the mines are great ledges of sandstone, along the edge of which the diggings are located. This sandstone extends over the country to an undetermined distance westward. At the mines it is underlain by the chert conglomerate.

About two miles east of Aurora, a sandstone belt, running in a north to south direction, crosses the country. It is thought to fix a limit to the mining area here, but this is by no means established. Drill-holes and shafts have shown the sandstone to be nearly 100 ft. thick.

South of Aurora, in Lawrence and northern Barry counties, Mr. Marbut describes these rocks at a number of localities. Conglomerate is abundant about Scholten, over an area of probably several square miles. It is here overlain by sandstone. At Washburn postoffice, sandstone 25 ft. thick is encountered. In the vicinity of Marionville, a large number of loose sandstone blocks lie over the surface. Other patches occur near Bethel and King's prairie, and near Butterfield, all in Barry county.

Prof. Shepard, who has given the subject most attention, in connection with his work about Springfield for the Geological Survey, has described a large number of occurrences in some detail. From these descriptions we have prepared the following notes.

At Graydon springs are very extensive exposures. The sandstone is here a more or less friable and usually micaceous rock, of red or purplish colors, sometimes gray. Just below the hotel, fragments of fossil leaves and other carbonaceous matter are included; also large calamites. Layers of shale are associated with the sandstone.

At Saway bluff, east of Ash Grove, a narrow ridge is capped with 70 ft. of the sandstone. It is well exposed where Clear creek cuts through this ridge. False bedding is exhibited. The contact with the underlying limestone is sharp and unconformable.

Three miles southeast of Graydon, on Ash Grove creek, is another similar ridge of sandstone.

At Warren's bluff, northeast of Strafford, are similar exposures of sandstone. It appears to be 100 ft. thick here. It is of very variable color, and some layers have nearly sufficient iron to be classed as iron ore. The rock is generally micaceous, but not always so. False bedding is well exhibited. Occasional water-worn quartz pebbles are encountered. Within 20 or 30 ft. of the summit of this ridge, chert conglomerate is found, which appears to cap the sandstone.

South and east of Strafford, conglomerates and sandstones of this formation are represented in small patches, and these extend north-westward, along a belt a few miles wide. In section 25, township 31 N., 21 W., such a strip is over a mile in width and of great thickness. The pebbles here are quite large.

About six miles northeast of Strafford, in section 9, township 30 N., 19 W., is what is known as Bodenheimer's mound. It rises nearly 150 ft. above the Pomme de Terre river. It is covered with pebbles of the conglomerate, some as much as 8 inches in diameter. The estimated thickness is about 70 ft.

Other mounds about here are similarly capped with these rocks. Prominent among these is the Fair Grove mound, in section 32, township 31 N., 20 W. It is about 150 ft. high, and is capped by 80 ft. of the conglomerate.

The Newton mound, in section 1, township 31 N., 21 W., is capped by 25 ft. of conglomerate overlying the Hannibal shale. Several similarly capped mounds occur immediately about this one.

South of Republic and east of Billings, the conglomerate is abundant over the surface. It occurs in a narrow patch extending north-westward through sections 35 and 26 of township 37 N., 23 W. Beyond this, in section 20 of the same township, it again appears, and extends thence a little west of north for a number of miles, in places as much as a mile wide. Prof. Shepard describes this outcrop in many places as resembling a natural cobble-stone pavement. The boulders are from 4 to 8 ins. in diameter, and some of them contain Lower Carboniferous fossils. Along the northern edge of the strip, the pebbles seem to decrease in size until they are no larger than rice grains. In the northwestern corner of section 20, township 27 N., 23 W., a well was sunk 23 ft. deep in the conglomerate. The pebbles decreased in size from top to bottom. When first excavated, the sandstone matrix was soft, but became hard on exposure. This deposit can be traced continuously to and beyond the railway cut east of Billings. The illustration of the preceding plate shows the nature of the deposit in that cut.

The unconformity of this Graydon Springs sandstone and conglomerate upon the Lower Carboniferous limestones below needs no further confirmation. It occupies the depressions in the latter rocks; it is in contact with different members at different places; and is made up of pebbles and boulders of Lower Carboniferous chert. These



COAL MEASURE CONGLOMERATE AND SANDSTONE, AT FULTON.

From photograph by H. A. Wheeler.

facts afford incontestable evidence of a long period of vigorous erosion between the time of consolidation of the Lower Carboniferous strata and the deposition of the Coal Measure rocks. It was a shore-line deposit, laid down, probably, in early Coal Measure times. Possibly, however, it may be a marginal deposit, representing a considerable portion of that epoch, and may have been forming while beds of the regular Coal Measures well up in the series were accumulating farther west.

This formation is, hence, of great stratigraphic interest, and is strong confirmation of phenomena existing elsewhere in the state. Thus, in Callaway county, there is similar evidence of unconformity. A great boulder deposit lies there at the base of the Coal Measures, in depressions of the underlying Lower Carboniferous rocks. The opposite plate is from a photograph of this exposure.

THE TERTIARY.

To the Tertiary period we provisionally assign certain deposits of gravel and clay which are strewn over the hill-tops adjacent to the larger streams in the extreme southwest, and which are found along the Osage and Meramec rivers, in the Central and Southeastern districts.

In the Southwestern district, these gravels are particularly abundant in the extreme western part of Jasper county; but they are also found along Spring river, in Newton county, and along White river. They are composed almost entirely of Carboniferous chert. The pebbles are not well rounded, but they are smooth and undoubtedly water-worn, and are of characteristic yellow or brown color on the exterior. They are essentially the same in character and distribution as the Lafayette gravels of Crowley's ridge, along the Missouri and the Arkansas river valleys. North of the Southwestern district, such gravels are abundant in Henry and St. Clair counties, along the Osage river and its tributaries. In southeastern Kansas they are abundant over the Neosho river drainage area, and have recently been described in some detail by Haworth [97, p. 136].

This formation in Missouri has not been sufficiently studied to attempt a detailed description, or to map its area. We therefore content ourselves with the following brief notes of occurrences at a few localities.

At Carl Junction this gravel occurs at the surface, immediately beneath the soil. It is encountered in many wells, and is generally several feet thick. Along Spring river, west of here, it is also found over the hill-tops.

At the mouth of Turkey creek, gravel was observed over the summit of the ridge, on the north side, about 80 feet above the bottoms. South of this, over the hills, along Spring river, it occurs frequently. South of the town of Galena, in what is known as the Spring Grove addition, water-worn chert-pebbles occur on the summit of the hills.

North of Carterville, between Center creek and Spring river, occasional patches of such gravel were observed by the writer. Farther up Spring river, near the Jasper and Lawrence county line, it was also seen. Its development along Spring river, west of Carl Junction, is, however, not great. Judging from the paucity of occurrences, these deposits probably never reached far, nor attained great thickness over eastern Jasper county.

Along White river, Mr. Marbut noted the occurrence of such gravel at a number of points given in the following table:

Township 23 N., 24 W., in section 21.....	110 ft. above White river.		
“ “ “ 33.....	100	“ “ “	
“ 21 N., 26 W., “ 28.....	120	“ “ “	
“ 21 N., 25 W., “ 2.....	170	“ King “	
“ 22 N., 23 W., “ 16.....	150	“ White “	
“ 22 N., 22 W.. “ 22.....	150	“ “ “	

Within the Central district, only a few occurrences of such gravels were noted. Just beyond the western limits of the district, however, about Osceola, they are quite abundant. The ground about the courthouse, in the town of Osceola, is covered with it. This point is about 60 ft. above the river level. South of this, along Sac river, occurrences are frequent. Eastward, however, down the Osage river, they are scarce. At station 15, on the Osage river map, such gravel was observed, covering the surface of the bluff about 30 ft. above the river. At station 37, a few miles above Warsaw, stratified sands and gravels were exposed on the north side of the river. These do not cap the bluffs, however, but seem to form a terrace. The top of this terrace is perhaps 30 ft. above the high-water mark of the present stream. In the town of Warsaw, chert and gravel was observed, covering the upland at an elevation of about 50 ft. above the river. These are all the exposures observed during the trip down the Osage. Lithologi-

cally, the gravel is similar, and in a general way it is distributed as are the gravels of Spring river and of the Neosho river. Additional observations are necessary, however, to satisfactorily settle the question of their age.

In the Southeastern district, there is a remarkable deposit of gravel along the Meramec river, which we assign provisionally, to the Tertiary age. It is well developed about a mile southwest of Pacific, along the Frisco railway. It is there dug and shipped to St. Louis, for road uses. It forms a terrace, rising above the river bottom 20 or 30 ft. It consists of pebbles of chert, cemented by ferruginous clay. Sand beds are also encountered, and these and the gravel exhibit false bedding. Blocks and fragments of impure iron ore are enclosed. These materials are such as occur in the rocks along the Meramec river above this place. They are, hence, all of local origin. The entire absence of northern material, such as constitutes the drift, is particularly noteworthy, and this especially as such material is found a few miles north. The absence of such northern material is evidence that these gravels were formed before the glacial epoch.

The gravels and clays of the different portions of the state, represent probably a period of partial submergence or of great increase in volume of the streams along which they occur. They doubtless filled pre-existing depressions of the country and removed inequalities, giving rise to the flat plains where undulating valleys previously existed. Though it is probable that the deposits now found are only remnants, it is improbable that the formation ever covered very wide areas. The deposits were apparently confined to comparatively narrow belts along the respective streams.

THE QUATERNARY AND RECENT.

Under this heading, we wish simply to call attention to the deposits of clay and other residuary materials which so abundantly cover the surface. In places these may have been in process of formation for an indefinite period, and hence may belong to different epochs. The greater part of what we now see, however, is probably of comparatively recent formation. However this may be, the great depths observed at different localities indicate a vast amount of surface decay.

Red Clays.—Red clays are abundant in the Southwestern district, about Carthage, Webb City, Joplin, and about Aurora, Ash Grove and

Springfield. They are especially thick over the massive beds of Burlington limestone. They are seen to occupy depressions and to surround pinnacles of this rock to depths of 10 or even 20 ft. A gradation from clay into decomposed rock is often traceable, and fragments of chert and limestone are often thus mixed in the lower portions of the clay.

Such clays are also abundant in the Southeastern district, in St. Francois and Washington counties. Great thicknesses are exposed in the cuts along the Iron Mountain railway, fine examples of pinnacle and decomposed limestone being visible in the cuts between Summit and Blackwell.

As is suggested by the gradations from clays into decomposed rocks, the former are, without much doubt, in great part residuary. An obstacle to entire reliance in this belief is the fact of the small amount of impurities which the limestones usually contain. Analyses show that this is only 3 or 4%. Possibly, with some admixture of undecomposed limestone, the residuary product might average as much as 10%. At some localities, the volume of the clay may have been increased through Tertiary submergence. This is, however, not possible in most places. We seem, therefore, forced to conclude that these clays simply represent the residues of a vast bulk of rock removed through sub-aerial decay. Clays similar to these are associated with some of the ore bodies; their origin will be referred to later.

Residuary Cherts.—Over areas underlain by cherty limestones, the ground is thickly covered with fragments of chert, residuary from the solution of the limestones. Immediately at the surface the clay is washed out, and we have simply a mass of chert fragments. Deeper down, the latter are mixed with more or less clay, and the material grades into undecomposed country rock. In the Southwestern and Central districts, these chert fragments are generally comparatively small and angular, gathered into deposits like shingle-beds. In the Southeast we find more nodular and drusy cherts; also large blocks and masses.

These cherts have already been referred to in the chapter on Physiography, under soils. The land occupied by them is largely worthless, and the hills they cover are known as flint hills.

In the vicinity of Fredericktown, Madison county, recent prospecting has developed a peculiar fact in the distribution of these cherts. Where great thicknesses of red clay are encountered overlying the

FIG. 1.



FIG. 2.



ILLUSTRATIONS OF SUB-AERIAL DECAY.

FIG. 1. LIMESTONE PINNACLES IN SOUTHEASTERN MISSOURI.

From photograph by G. E. Ladd.

FIG. 2. RESIDUARY CLAYS AND DECOMPOSED LIMESTONE IN SOUTHWESTERN MISSOURI.

From photograph by W. P. Jenney.

rock, the residuary chert is not found resting on the limestone, but above the clay and near the surface. The bed of chert is from 3 to 6 ft. thick, while the underlying clay is generally from 30 to 40 ft. deep, and in places as much as 100 ft. These developments have been over the hills adjacent to the St. Francois mountains. The position of the chert indicates that it has been derived from overlying cherty beds, and that the decomposition of the limestone which contains no chert has proceeded under this covering. Possibly, in some instances, the chert has crept down the hill slopes from an originally higher location.

STRUCTURAL GEOLOGY.

Under this heading, we shall briefly refer to such structures as flexures, faults, fissures and crevices, and this purely with regard to their geotectonic relations. No pronounced system of flexures and no great regional faults are recognized in the area. In the radial or quaquaversal dips of the rocks away from the Ozarks, we have one great master flexure. Subordinate to this, certain minor flexures are recognized, but they are so gentle or so small that they are to be regarded as mere undulations or wrinkles. Similarly, there are some well-marked faults, a larger number of minor ones, and a great number of joints and crevices unaccompanied by movements.

A certain parallelism between some of these flexures and fractures and the sides of the Ozark dome is observable, and such may be included in one class. Others are, however, at right angles to the central uplift. A few of these, which have been specially observed, we will now describe briefly :

The Southwestern District.—In the Southwestern district, we have at Mansfield, in Wright county, a fault running N. 30° W., nearly parallel with the Ozark dome. This is fully described in the descriptions of the mines at that place, given later. The amount of the throw could not be determined, but it is probably not over 100 ft., and very likely less.

Along White river, no very prominent faults were observed by Mr. Marbut. At Big Sugar creek, in McDonald county, near the Carboniferous, the sudden appearance of magnesian limestone high up in the hills suggests the presence of a fault. In the southeastern part of township 21 N., 34 W., in Stone county, there is another change in altitude in the same rocks of about 200 ft. This Mr. Marbut calls

attention to as being in the line of a fault, running near Green Forest, in Arkansas, and referred to by Mr. Hopkins [111, pp. 329, 413]. The down-throw is on the east side. Mr. Edwin Harrison has called the writer's attention to another line of disturbance or faulting in Taney county, which apparently crosses White river in a NNW. to SSE. direction, about 6 miles west of Forsyth. The faults of the Arkansas marble region, described by Mr. Hopkins, undoubtedly entered into Missouri.

In the vicinity of Springfield, Prof. Shepard has recognized a number of faults. Along Pierson creek, near the mines, Burlington limestone is brought alongside of Chouteau. Near McCrackin's mill, section 5, township 29 N., 21 W., the Louisiana limestone is brought to the level of the Upper Burlington beds. Prof. Shepard is of the opinion that this fault can be recognized farther north. Between Buckley and Sac river to the north, he recognized a succession of faults with throws of from 2 to over 200 ft. Further work seems necessary, however, to fully establish the presence of these. In section 9, township 31 N., 23 W., others are recognized by Prof. Shepard, and, according to his observations, they are abundant over the county on both sides of the Polk and Greene county line, in the vicinity of Sac river and its tributaries. That the rocks are flexed in this strip of country, has been observed by the writer, and further, the Lower Carboniferous and Silurian are doubtless unconformable here, as elsewhere. These two conditions might bring the rocks into such relations that faulting would seem to have taken place, and we are inclined to think that such is the case.

In the observations made along Spring river, Shoal creek and other streams in the western part of the district, no evidence of great faulting was seen. About the mines of Newton and Jasper counties, much local slipping and brecciation has taken place. This is, however, not due to crustal movements, but rather to surface decay and subterranean erosion of the limestone country rocks.*

Joint-planes and crevices are abundant throughout the district. They are exhibited in the diggings on Pierson creek, on Swan creek, Bull creek and of Elk valley south of Ozark, and at other points where

* In a recent paper [27], Prof. Wm. P. Blake adduces the juxtaposition of Coal Measures and coal with older rocks, on the Oswego tract near Joplin, as evidence of faulting. That he has been misled by the deposits known as coal pockets, already referred to in this report, and abundantly described later, is plain. To one not familiar with these pockets, which are peculiar to Missouri, they are liable to be misleading in many ways [250 - p. 171].

deposits in crevices have been worked. The prevailing course of these crevices is northwesterly, and they are, hence, parallel to the Ozark dome.

Local flexures are recognizable in the central and eastern portions of the district. Prof. Shepard has noted such in the vicinity of Springfield. They are generally exhibited by local exposures of dipping rocks. They cannot be traced any great distance, however, and their distribution is obscure. One of the most pronounced observed by the writer is a monocline in eastern Polk county, located by Maj. E. W. Newton of Bolivar. It is just west of Fair Play, and beyond the district limits. It apparently extends southward into Greene county. The dips amount to 10 and 20° in places, and are nearly due westward.

The Southeastern District.—In the southeastern district, one of the best marked and well-established faults traverses the Mine La Motte estate, about three miles north of the mines. It is described in detail later. The strike is northeast and southwest, thus conforming to the Ozark uplift. The down-throw, which is on the north side, amounts to over 300 ft. Other parallel faults of less extent also traverse this estate. In southern Jefferson county, a line of disturbance can be traced from the Mammoth lead mine southeastward, past Vineland. A similar line of disturbance is recognized north of the Valle mines, and the two are doubtless connected. They have already been described in some detail (pp. 351, 355). The course is, in a general way, parallel to the Ozark uplift. The disturbance does not consist of a single fault, but of a series of breaks combined with much flexing. Probably the whole throw does not amount to very much.

In Franklin county, there are a number of faults exhibited at the different mines. The extent of the throws is not demonstrated, but they are probably not great. The direction of these fault-planes is nearly N.-S., and they are thus nearly at right angles to the central uplift.

East of Farmington, we have already (p. 350) referred to the presence of an anticlinal axis running apparently in a direction a little W. of N. It is a gentle flexure, and apparently dies out northward. Southward it may be expressed in the faulting at Mine La Motte.

West of Potosi, adjoining Washington county, evidence of some disturbance is presented by dips of the strata, amounting to as much as 10° or 15° in places. These appear, however, to be entirely local.

Crevice following probable joint-planes are abundant in the Southeastern district. In Franklin county, many of the ore deposits occur in such. Like the faults, these crevices run in a nearly N.-S. direction, and are thus at right angles to the uplift. At Bonne Terre, numerous crevices are also encountered in the mines. They run in all directions, but the more important trend E.-W., or somewhat north of east. They are thus also at right angles to the uplift. At Mine a Joe, on Flat river, crevices worked in earlier years were almost due E.-W. At Doe Run, crevices run in various directions, but principally N.-S., or somewhat east of south.

The Central District.—In the Central district flexures were observed along the Osage river, and have been described. They are small and probably not traceable very far along their trends. Those whose direction can be best traced ran in a northwesterly direction, and were thus nearly at right angles to the uplift. No noteworthy faults were observed.

Along the Missouri, several flexures have already been referred to. Their axes could not be determined, but they are probably parallel to those of the Osage river.

The most pronounced dip seen in the district is south of Linn Creek, near Gunter spring, and is described on page 377.

On the Camden and Laclede county line, at the Wheeler mine, in section 32, of township 37 N., 16 W., is an area of intense local disturbance, illustrated in figure 114. With this is associated an erupted dike or boss of pegmatite. Special interest attaches itself to this outcrop, as it is the only one of post-Archean age found in the Mississippi valley, with the exception of the Mesozoic eruptives of Arkansas. Further, it is the only indication we have that igneous action or metamorphism accompanied the crustal movements of the Ozark uplift. The actual exposure of pegmatite does not exceed a few square yards, and, had it not been that the locality was prospected for lead, its presence might never have been detected.

The country rocks are principally magnesian limestones; with them are some sandstones; they are normally horizontal and undisturbed. Immediately about the pegmatite, however, they assume abnormal and rapidly varying dips. Similar conditions have been nowhere observed within the Ozark area, and, in themselves, they are sufficient to have distinguished this locality as one of somewhat intense, though local, disturbance. These conditions are represented on the small map, con.

structed from a survey of the area. The short, heavy black lines represent outcrops, and the arrows the dips.

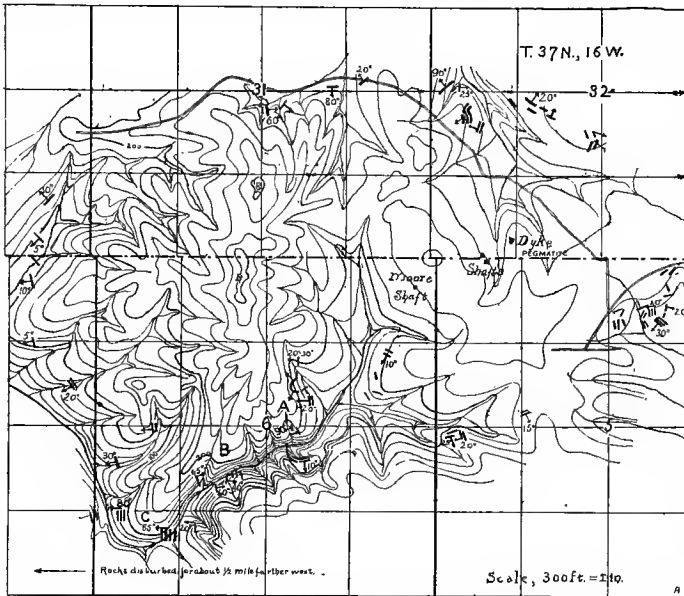


FIG. 114 Map showing area of disturbance contiguous to Pegmatite Dike.

From this map it will be seen that to the north, east and south of the pegmatite, the disturbance does not extend very far, nor are the dips excessive. To the southwest, however, the disturbance can be traced some two miles, and at points it is quite intense. It is further noticeable that the dips are generally away from the dike, as if this were the center of the disturbance. Exceptions to this, and steep and confused dips at other localities, such as those marked A, B and C, suggest that there were other centers also, and that eruptive rock may exist elsewhere, not far beneath the surface.

The rocks of the dike consist of a graphic granite, or pegmatite, and of white mica. These do not seem to be distributed or arranged in any special order, unless it be that the mica prevails near the contact with the surrounding rocks. The dike seems to have the form of a boss or neck, which has pushed its way up through the rocks. The structure of the pegmatite proper is in part that of a true graphic granite consisting of long crystals of quartz, surrounded by feldspar; sometimes it is granular. It is always fine-grained, the quartz crystals not exceeding a fourth of an inch in diameter. Sometimes, masses of quartz

are found with no admixture of feldspar. The mica forms a rock composed of very small crystals or scales. Prof. Erasmus Haworth, who examined specimens, reports that he found only one mica, muscovite. Microcline is the principal feldspar, but the acid triclincs are present in small amounts. These are probably albite and oligoclase, both or either, and, possibly, orthoclase. The rock is much decomposed at the outcrop, and is mostly soft and incoherent. No contact metamorphism of the country rocks could be detected.

The disturbed condition of the rocks surrounding the pegmatite is in support of the view that the latter was originally molten, and that it was intruded. That it was formed by aqueo-igneous fusion, as such rocks are commonly believed to be formed, there is no reason against. That it is purely a result of segregation or alteration of rocks *in situ*, as has been maintained by some concerning other pegmatites, is opposed to the facts. It is not probable that this intrusion or eruption ever reached the surface. No traces of volcanic rocks are now found in the surrounding country, and the small size of the outcrop indicates that the present exposure is near the apex of the boss or neck.

The exact age of the intrusion cannot be determined. That it was post-Lower Silurian is self-evident. We are inclined to assign it to the time of the last great uplift of the Ozarks, which was immediately after the Coal Measure epoch, and which was probably the greatest crustal movement that took place over this area.

CHAPTER XI.

THE GEOLOGIC HISTORY OF SOUTHERN MISSOURI.

Having now described with some fullness the geology of the mining districts, we are prepared to attempt an outline of the history of southern Missouri, of which these districts constitute a large part. We mean by this a history of the processes and events by which the features and phenomena described have been produced. This is of much importance to the correct interpretation and understanding of the ore deposits. Just as from the history or record of an individual, we can predict something of his capabilities and future; so, from the history of a region, we learn to understand the meaning of its features. Though, in the present state of our knowledge of such a complicated subject, positive statements are not always possible, much can be said which will be suggestive and profitable in directing future inquiry. In what follows, we shall attempt to describe the conditions and events of different geological eras or periods, beginning with the oldest, the Archean.

The Archean Era.—The Archean land surface of this portion of the globe must have been a very extensive one. At the beginning, at least, it probably spread well beyond the state limits. Its original outlines are at present undefinable; but, from the fact that the rocks of the present land must have been originally derived in part from these pre-existing Archean rocks, the mass exposed to denudation must have been very great.

The Algonkian Era.—Before the end of the Algonkian era, the Archean land surface of Missouri was entirely submerged. Whether this condition was reached during the late Algonkian or during the early Algonkian, we are unable to say. Probably there was a gradual lowering, such that complete submergence was not accomplished till toward the end. The extent of the Algonkian deposition is unknown and undeterminable. The only considerable exposure at present is the small patch on Pilot knob. Possibly, rocks of the same formation are

represented under the surrounding paleozoics; of this, however, there is no positive evidence, excepting, perhaps, in the record of a deep drill-hole put down at Raytown, south of Kansas City. Here the base of the Paleozoic rocks was reached at a depth of 2430 ft., and below this, 36 ft. of crystalline rock were penetrated. A specimen of this core in the possession of the writer, is a highly micaceous schist, composed almost entirely of black mica. It is different from any rocks found in the Archean of the southeast, and is more like rock referred to the Algonkian elsewhere. A drill-hole at the St. Louis insane asylum 3600 ft. deep, one at Carthage about 2000 ft. deep, and one near Sullivan, Franklin county, about 1200 ft. deep, all reached crystalline rock. In the first, this is reported by Prof. Broadhead to have been granite; in the second, Mr. J. D. Robertson determined the specimen to be porphyry; in the third, drillings examined by the writer consisted of pink feldspar and quartz like those of the Archean granites. These last results, therefore, are opposed to the existence of Algonkian rocks at the respective localities. Such may have existed there, however in the past, and have since been removed.

The Cambrian Period.—During the Cambrian period, Missouri was probably a land surface, at least in large part. This conclusion is reached, first, because there is either only a very limited thickness or no rock of this age in the state; and, second, because there is evidence of very great erosion, requiring a long period of time, between the Algonkian era and the Silurian period. During this interval, all but the small Pilot knob patch of Algonkian beds were entirely removed, and the underlying Archean granites and porphyries deeply trenched. It is to this date that we must assign the original sculpturing of the hills and valleys of southeastern Missouri, around and between which the Silurian limestones were later spread. To have eroded this great mass of resistant Algonkian and Archean rocks, must certainly have taken a long period, even geologically considered. Possibly, this elevation and erosion may even have begun well back in the Algonkian time, and have continued through the Cambrian. This would make the maintenance of the conditions of emergence still longer, and would make the almost complete removal of the Algonkian beds more readily understood. It is, however, possible that this land surface was only in the vicinity of the St. Francois mountains, and that Cambrian beds now exist in the deep basins away from there, especially to the northeast. Of this we have no local evidence to present, however.

The Silurian Period.—Early in the Silurian, or possibly before the end of the Cambrian, well-nigh the whole of Missouri must have been submerged, and the deposition of the rocks of the Ozark stage begun. Before the end of the Lower Silurian epoch, it is probable that a re-elevation took place, exposing a large land surface to erosion. We conclude this because we are of the opinion that the Trenton and higher Silurian strata never covered the whole Ozark area. There is no positive evidence of their former existence there. The absence of any remnant or outlier, and also the absence of these rocks between the Devonian and Lower Silurian formations of the extreme southwest, are both facts opposed to the idea.

The same applies to the Crystal City sandstone, though to a less degree. Lithologically, this formation has more the character of a fluvial or estuary deposit than of a wide-spread sandy stratum. The flow structure or false-bedding frequently exhibited is in harmony with this idea. The unconformity with underlying rocks, exhibited at many localities, shows that an erosion period preceded its deposition.

At the end of the Silurian period most of southern Missouri, or of the Ozark uplift, was, without much doubt, well above water level.

The Devonian Period appears to have been essentially one of emergence in southern Missouri, and to have remained so throughout. As with the Trenton and Upper Silurian strata, there is no positive evidence, in the nature of outliers or residuary products, of the former presence of Devonian rocks over the Ozarks. Along the western border of the uplift, the formation is also absent between the Ozark stage of the Lower Silurian and the overlying Lower Carboniferous strata, with the exception of where the Eureka shales come in, in McDonald county. Similarly, they are absent along most of the eastern border; while along the northern border they occur in thin patches, as if filling estuary-like depressions in the margin of an old land mass. This, therefore, we also class as a long erosion period, during which the Ozark rocks were extensively denuded and perhaps even base leveled. During this interval, the inequalities of the surface were produced which caused the oft-observed unconformity of contact of the later deposited Lower Carboniferous beds.

The Lower Carboniferous Epoch.—At the beginning, and possibly before the Lower Carboniferous epoch, a submergence began. The waters crept up over the uplift, seizing hold of the insoluble products

of sub-aerial decay of the Silurian rocks to make shales, sandstone and chert conglomerates, filling in great erosion depressions with these, and dissolving the lime to assist in the formation of the Lower Carboniferous limestones. This movement continued probably for a long time, though at a very slow rate. From the fact that fragments of Lower Carboniferous chert are found over the surface as far into the interior of the area as Howell and Crawford counties, the waters must have reached that far. Whether they extended beyond this to the Archean area is doubtful. No remains of these rocks are found there. It is probable, however, that estuary-like arms from the Illinois area reached westward into Missouri.

It is further probable that the submergence of the central portion of the Ozarks did not last long, that only a thin stratum, or somewhat isolated patches of rock were formed, which were soon and readily removed later. The mass of the rocks were probably deposited around the flanks, and ran out to a feather-edge toward the interior.

The uprise probably began well before the end of the Lower Carboniferous, and continued until about all of southern Missouri became a land surface. A long-continued period of emergence followed this, during which denudation must have been very vigorous. The surface became deeply trenched and covered with residuary materials. This caused the unconformity of the overlying Coal Measures, and supplied abundance of material for the fragmental rocks which form the base of that series.

The Coal Measure Epoch.—Early, probably at the beginning of the epoch, a renewed submergence and sequence of events took place, similar to those immediately preceding the deposition of the Lower Carboniferous rocks. The waters again crept inland and upland, availing themselves of the products of sub-areal decay for the making of new sediments, such as shales, sandstones and chert conglomerates or boulder beds. These soon filled the depressions and spread themselves over the surface. The submergence probably did not extend as far inland as that of the Lower Carboniferous epoch. It was doubtless, however, far beyond the present Coal Measure margin. Outliers and coal pockets in the interior counties indicate a wide extension, but some of these could have been, and probably were, formed in inland lagoons. That they are sometimes surrounded by Silurian rocks shows that Lower Carboniferous or other intervening strata, if ever present

at such points, had been removed prior to the Coal Measure deposition. This epoch, though one of fluctuating movements, was, on the whole, characterized by a sinking of the area surrounding the Ozark uplift. A reversal of the movement inaugurated the Mesozoic.

The Mesozoic Era.—With this era we have little to do. No rocks of the formation are represented in the state. At the beginning, all of Missouri was above sea-level for the first time, and has continued so ever since, with the exception of the Mississippi embayment. This era is noteworthy, however, as marking the beginning of the present drainage system of the state. Heretofore, during various uplifts, a radial drainage from the center of the dome was undoubtedly developed and obliterated with each succeeding submergence. With the post-Carboniferous uplift, the Mississippi valley was probably first defined, as a result of the Cincinnati and Ozark uplifts; while the Missouri river valley appeared as the result of these and of the Wisconsin uplift. The present drainage began with a radial flow of water from the center of the Ozarks. Traces of this are still seen in the distribution of the streams of that area. At the beginning, the Missouri river was probably only rudimentary, its head being within, or at least not very far beyond, the western border of the state. This was so, because a divide must have existed in western Missouri or eastern Kansas, beyond which the waters flowed westward into the Mesozoic seas.

The Tertiary Epoch.—The conditions of the Mesozoic trenching, land-sculpturing and sub-aerial decay, probably continued well into the Tertiary epoch. Then, with the uplift of the western country, a great change in the drainage took place; divides were transferred westward to the Rocky mountains, and the Missouri river assumed something of its present proportions. It was probably somewhere about this time that the partial over flow or great rise of the streams of southwestern Missouri took place, producing the deposits of gravel which we have described. All of the Ozark area proper, however, continued above water-level, and has since that time been subjected uninterruptedly to denudation.

Conclusions.—Among the most important facts brought out by this sketch, are the long periods of sub-aerial decay to which this Ozark area has been subjected, especially the one since the post Carboniferous uplift. The surprising thing is that the whole country has not been completely base-leveled. Changes of level have doubtless prevented this in part; but, in addition, the comparatively gentle slopes and low altitudes,

and the absence of glacial action, have supplemented this. The residuary products of decay have thus accumulated over the flat surfaces to great depths, and they have protected the underlying rocks. The limestones, it is true, are not specially resistant, but the associated chert beds have protected these. Further, from the fact that the climate was not arid, and that the country is not and has not been at a great altitude, the surface has been well covered with vegetation. The declivities of the larger streams have not been great enough to corrade rapidly. To these causes we attribute the lasting qualities of this area.

The earth movements which took place were, apparently, of the nature of great pulsations, alternately raising and lowering the surface. Along the eastern border, a sharper monocline seems to have been developed, as is exhibited in the comparatively steep dips of eastern Ste. Genevieve county. This feature accounts for the greater declivity of the streams toward the east and the proximity of the divide to the Missouri river. The presence of the Archean rocks so near the surface here, doubtless had its influence in locating this flexure.

As we have seen, no violent movements, accompanied by flexing or faulting, seem to have taken place. Since the Archean time there has been no extravasation of igneous rock, and no intrusion of such, excepting, perhaps, in the case of the Camden county pegmatite. This we think took place at the time of the last great uplift, succeeding the Coal Measure epoch.

CHAPTER XII.

THE ORE DEPOSITS — A GENERAL DESCRIPTION AND DISCUSSION.

DISTRIBUTION —THE FORMS OF THE ORE BODIES —THE COMPOSITION OF THE ORE BODIES —THE STRUCTURE OF THE ORE BODIES.—THE MODE OF FORMATION OF THE ORE BODIES.—THE ORIGIN OF THE METALLIFEROUS AND OTHER MINERALS.

In preceding chapters of this report, we have described and discussed the general geology of the different mining districts. In part III will be given, in great detail, an exact description of all the important occurrences and developments of ore. In this chapter we shall confine ourselves to a generalized description and discussion of the ore deposits as a whole.

DISTRIBUTION.

Geographic Distribution.—The geographic distribution of the ore deposits is so clearly shown on the accompanying maps, and is so fully described in part III, that little further need be said here. To be specially noted, however, is the bunching of the deposits about certain centers, and their comparative absence elsewhere; also, the preponderance of lead ore in the Southeastern and Central districts, and of zinc ore in the Southwestern.

Geologic Distribution.—In the southwest, almost all of the deposits are in Lower Carboniferous limestones and cherts. Some are in close proximity to patches and pockets of Coal Measure shales and sandstones, but no considerable deposits are enclosed in the latter rocks. A few are in magnesian limestones of the Lower Silurian area, but these are comparatively unimportant. In the Lower Carboniferous, the deposits apparently range from the lower Kinderhook beds to the Burlington and Keokuk; but in Jasper, Newton and Lawrence counties, where are the most important, they are confined to the last two sub stages.

In the Southeastern district, the deposits are in the Lower Silurian limestones (and Cambrian if such exist). The larger lead deposits are

in the massive strata near the base, which form the St. Joseph limestone. Other lead deposits, and such zinc ores as exist, occur higher in the sections, in the cherty Potosi limestones. The sandstones are noticeably deficient in ore. The great basal, La Motte sandstone marks, practically, the lower limit of the ore in St. Francois county, though galena is sometimes found a little below the contact. At Mine La Motte, and at the Avon mines, some little ore is obtained from the sandstone. Further, in Franklin county, veins traverse strata of sandstone; but the magnesian limestones are there also, normally the ore bearing rocks.

In the Central district, all of the deposits are in the Lower Silurian limestones, principally in what we term the Osage limestones, but also in the Jefferson City limestone. Sometimes they are associated with remnants of Lower Carboniferous rocks and Coal Measure shales.

THE FORMS OF THE ORE BODIES.

Ore bodies of massive, lenticular, tabular and cylindrical forms exist in all three districts; but certain forms, abundantly described in later chapters, especially characterize each district.

Thus, in the southwest, especially in Jasper, Newton and Lawrence counties, the massive form prevails. Here we have great bodies hundreds of feet in diameter, which, when removed, leave cavernous spaces. These may best be called cavern deposits. Sometimes they are covered, sometimes they reach to the surface. Deposits of other forms also occur in these counties, but they are generally only modifications of the prevailing type. Sheets and pipes sometimes extend from the main ore body into surrounding barren ground, but these are subordinate. In Christian and Greene counties, tabular or sheet forms filling vertical crevices are more common, though the massive, cavern deposits occur here also.

In the southeast, we have as typical forms, the massive deposits of Madison and St. Francois counties. Here, however, instead of being cavernous, they are impregnations of great masses of magnesian limestone. Occasionally, tabular deposits, filling vertical crevices, are associated with these. In Jefferson and Washington counties, we have as prevailing types, tabular and lenticular bodies in horizontal positions; also pipe and cylindrical deposits and stockwerks associated with these. In Franklin county, the tabular deposits in vertical crevices, or veins are the common forms.

In the Central district are a number of instances of deposits of massive forms, such as at the High Point mine; tabular bodies in vertical crevices are, however, most common. Small lenticular bodies, almost nodular, and a few pipe or chimney deposits, are encountered.

THE COMPOSITION OF THE ORE BODIES.

These, like all other ore deposits, are made up of mixtures of gangues or vein stuffs, and of minerals, metalliferous and others.

Among gangue materials we recognize the following: 1) country rocks, principally cherts and limestones, specially abundant in the southwestern deposits; 2) clays in several varieties, found in all three districts; 3) sands and shales; 4) secondary cherts; 5) secondary limestones; 6) dolomite; 7) barite.

Among minerals, we recognize metalliferous and non-metalliferous, which we will enumerate later.

The Gangues of the Ore Deposits.

Country Rocks.—The country rock occurs as a constituent of ore bodies in two forms: 1) in fragments; 2) massive.

The fragmental form characterizes especially the Southwestern district. Here, as the descriptions abundantly show, the ore bodies are huge accumulations of breccia. The fragments are principally chert derived from the country rock. Some limestone also occurs, but it is an unimportant constituent. Sometimes, blocks of Coal Measure sandstone, shale, and even coal, occur in this breccia, as the result of a later secondary disturbance and rearrangement of the materials. The chert occurs in large slabs or blocks, as in the original rock, or it may be very much shattered and comminuted. The fragments are all angular, and not water-worn. They are sometimes corroded, and contain blende or galena in the crevices or cavities, but these minerals are never diffused through them. Another class of fragments occurs in the Southeastern district. These are water-worn boulders and pebbles of granite, buried in a limestone matrix which carries galena. They are abundant at the Doe Run mines.

Country rock in the massive form constitutes an integral part of the typical ore bodies of the Southeastern district. Here the galena is disseminated through rock. Similar conditions occur elsewhere also, as in the Pierson creek mine, in Greene county, where galena is diffused through a shale called "gumbo."

Clays.—Clays of several varieties are found in almost all of the deposits, though they are least abundant in the massive, disseminated bodies of the southeast. The color is generally red, but it may be yellow, brown, black, and even white. They are generally plastic and are mostly quite pure, but they are sometimes loamy and sandy.

They are abundant in Jasper, Newton and Lawrence counties and, in the less consolidated deposits, they surround the fragments of the breccias and have the ore imbedded in them. They also occur in vertical crevices in Christian and Greene counties, and in the flats, pipes and crevices of Washington, Jefferson, Crawford and other counties of the Southeastern and Central districts.

Doubtless, they are, in most cases, derived from surface decomposition of the country rocks, and have been washed into their present positions by surface waters. Their red colors show that oxidation has been active.

Some of these clays are of extreme homogeneity and are, doubtless, chemically deposited. These are found filling cavities, often only filling the lower parts, and showing distinct stratification marks. Such grade into what is known as tallow clay, and are, thus, frequently mixtures of silicate of alumina and iron and of silicate of zinc, of particular interest because of their high zinc contents. They are quite abundant in places, but the variability in the quantity of zinc contained, and the difficulty of separating the higher from the lower grades, have prevented their use. The opposite table of analyses shows their compositions.

Sands and Shales.—We refer here to certain materials especially found in Jasper county, and also at Galena, Kansas. The sands are highly siliceous, and apparently result from decomposition of cherts or quartzites. Sands composed of grains or crystals of dolomite are also found, but these we shall refer to later. Among shales we include earthy sands, and non-plastic clays. These are sometimes partly consolidated. They grade into sands on the one side and into clays on the other. They are very abundant in the southwestern mines and, when black and mixed with water, are known as black mud.

Secondary Cherts.—These are extremely interesting gangues, composed principally of amorphous, chalcedonic silica. They are confined almost exclusively to southwestern Missouri, and particularly to Jasper county and adjacent parts of Newton county. In the mines of Galena, Kansas, they are very abundant.

TABLE OF ANALYSES OF MISSOURI TALLOW CLAYS.

Nos.	Location.	Hydroscopic water.	Combined water and organic matter	Silica.	Ferric oxide.	Alumina.	Zinc oxide.	Lime.	Total.	Analyst.	Survey, Anal.	Reference.	Remarks.
1	Jasper county— Joplin.	8.30	9.20	35.50	9.50	5.42	30.33	2.23	92.61	Robertson ..	393	Mo. Geol. Sur.	Black, Croseman & Co.; 1000-acre tract.
2	"	18.05		42.40	6.03	30.48	2.36	1.70	101.00	"	397	"	Black, very soft; Kohnmoor shaft, Empire Co.
3	Lawrence county— Aurora.	9.97	7.19	34.53	2.59	6.41	37.23	2.20	99.52	"	395	"	Salmon, Porter and Coates' shaft, Louisville Co.
4	"	11.65	6.94	32.44	2.17	5.53	38.90	2.58	101.01	"	396	"	Light red, Louisville Co.
5	"	{ 2.43 to 10.50	{ 8.36 to 10.38	{ 33.66 to 66.22	{ 0 to 8.44	{ 1.64 to 10.62	{ 4.30 to 54.92	{ 0 to 1.80		W. H. Seamon		Am. Jour. Sci., 3d. vol. xxxix p. 40.	White to reddish brown—extremes of 12 samples.
6	Polce City	{ 3.63 to 10.78	{ 3.52 to 9.38	{ 33.36 to 37.66	{ 0 to 8.53	{ 1.62 to 11.03	{ 34.33 to 66.12	Trace		"		"	White to reddish brown—extremes of 6 samples.
7	Newton county— Granby.	5.03	8.28	34.56	3.03	15.6	28.40	4.99	99.00	Robertson ..	394	Mo. Geol. Sur.	Dark red, Butler shaft.
8	"	4.87	6.01	38.25	3.36	3.67	21.87	1.22	99.85	"	398	"	Dark red, Butler shaft.
9	"	10.90	7.15	42.16	2.64	7.70	27.80	1.40	99.75	"	399	"	Dark red, Woodcock & Turner's shaft
10	"	9.35	9.67	32.48	1.07	7.85	37.32	2.22	99.96	"	400	"	White, Woodcock & Turner's shaft.
11	"	13.33		43.63	27.96		14.98		99.95	R. Chauvenet.		Rept. 1573, p. 407.	Brown, friable.
12	"	{ 4.87 to 12.50	{ 4.13 to 8.02	{ 30.27 to 56.82	{ 0.01 to 4.46	{ 1.85 to 8.76	{ 34.78 to 30.36	{ 0.08 to 2.31		W. H. Seamon		Opus chte....	Extremes of 4 samples.
13	Phelps county	8.49	12.72	64.97	0.11	3.81	5.17	Trace	100.27	"		"	

They vary in color, being black, brown, drab, and even white. In texture they may be glassy or granular, and they range in hardness from that of quartz to the softness of shale. They furnish indubitable evidence of great secondary silicification. Fragments of the original white chert are held so firmly by this secondary chert, that, when a block is broken, the fracture passes through the enclosed fragments, without even loosening them from the matrix. Often, the whole ore body becomes thus one compact hard rock, which is mined with great difficulty. Sometimes, the solutions of silica have partially redissolved the original chert, and the two grade into each other.

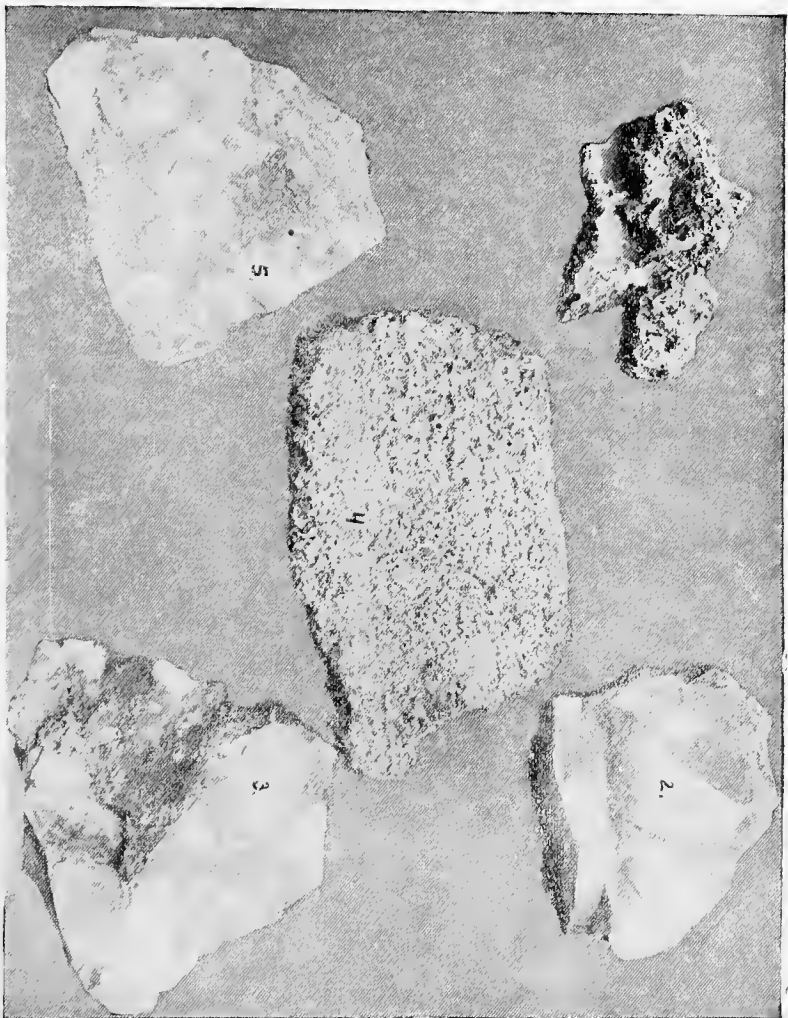
The silicification and consolidation of this matrix was evidently later than the formation of the blende, galena and dolomite, as well-formed crystals of these minerals are held enclosed; often, perfect interior casts of such crystals are left by their dissolving out from the matrix. In the case of dolomite, they are frequently so abundant that their removal leaves a rock of tufaceous texture. Examples of this are shown in the opposite plate.

The siliceous solutions, permeating the clays and sands which were already present in the ore bodies in greater or less quantities, cemented them, which accounts for the differences in composition and color of these gangues. Where silicification was only partial, the material is less indurated and grades into a shale.

At the Corry mine, in Dade county, a variety of secondary chert occurs, which is called "mineral rock." It is light colored, porous, often vesicular, with minute quartz crystals lining the cavities.

The opposite table of analyses shows the composition of these secondary gangue cherts.

A microscopic examination was made of a few specimens. One, (No. 3764) from the Bonanza shaft, Aurora, is of dark gray, bluish color. Macroscopically it has a semi-vitreous luster, is homogeneous and finely granular. It has a sub-conchoidal fracture, is very hard, brittle, feebly translucent on the edges, exhibits no effervescence with hydrochloric acid, contains a few glistening crystal faces, and weathers brown. Microscopically it is composed of a microcrystalline base, made up of doubly refractive grains not well defined and without crystal forms; micro-granules are diffused through this. There are also larger, dark, opaque grains of greenish, yellow and black colors, and numerous clouded, translucent grains, milky white in reflected light, which seem to be granular in structure.



SECONDARY CHERT GANGUES.

- NO. 1. VESICULAR CHERT FROM CORY MINE, DADE COUNTY.
2 AND 3. BRECCIA OF FRAGMENTS OF WHITE, ORIGINAL CHERT, HELD IN DARK SECONDARY CHERT, FROM GALENA, KANSAS.
4. DARK SECONDARY CHERT FROM WHICH DOLOMITE CRYSTALS HAVE BEEN DISSOLVED OUT; FROM SNYDER BRO.'S. MINE, JOPLIN.
5. BRECCIA, SHOWING PARTIAL SOLUTION OF ORIGINAL WHITE CHERT.

TABLE OF ANALYSES OF SECONDARY CHERT GANGUES.

No	Locality.	Insoluble siliceous residue.	Combined oxides.	Calcium carbonate.	Magne-sium carbonate.	Total.	Analyst.	Survey Nos.		Remarks.
								Anal.	Cat.	
1	Jasper Co., Joplin, Oswego land.	91.23	3.51	5.06	0.17	99.97	Robertson	352	3733	Soft grey, looks like calcareous sandstone.
2	" " "	86.98	3.09	9.62	0.81	99.50	"	516	.....
3	Webb City, Victor mine	76.86	12.45	9.98	2.22	100.51	"	378	3736	
4	Joplin, Snyder mine	64.03	3.77	26.43	26.80	99.65	"	515	3741	Soft, clayey.
5	Webb City, Rich-land mine.	93.69	5.60	1.30	Trace	100.59	"	346	3732	Dark brown, earthy, abundance of dolomite crystals enclosed.
6	Kansas, Galena, Wellup mine.	86.19	11.64	2.77	0.15	99.76	"	379	3500	Dark, brownish, hard, somewhat porous, banded like shale.
7	" " Marth & Hughes	97.75	1.61	.80	Trace	100.16	"	517	3814	Soft, clayey, like decomposed limestone.
8	" " "	92.28	1.25	Trace	4.08 ZnS	99.68	"	518	3794	Light drab, porous, like a fine-grained, open dolomite.
8	Newton Co., Emilie mine	95.21	3.63	0.60	Trace	99.39	"	364	3045	Dark brown, hard, somewhat granular and earthy, small crystals blende. Hard, crypto-crystalline.

The specimen from the Emilie mine, south of Joplin (No. 3045), is of dark, brownish gray color, of finely granular texture and rough surface. Under the lens, it is homogeneous, excepting for a few glistening crystalline faces. It does not effervesce with hydrochloric acid, is hard and brittle, with a sub-conchoidal fracture and an opaque, dull luster. Microscopically, it is seen to be composed of minute, opaque grains, uniformly diffused through a microgranular and translucent ground mass, containing micro-lithic inclusions, and a few opaque scales of a yellow color. The ground mass is mostly doubly refractive and microcrystalline; but the crystals are not well defined or individualized, and are mingled with isotropic individuals. A few strongly doubly refractive grains were noticed, which are possibly calcite.

Limestones.—In some deposits, particularly in Jasper county, galena and blende crystals appear to be held in limestone. This is a secondary rock, formed in the ore bodies, and cements the chert and other fragments. Crystals of blende frequently fall out of this matrix, leaving perfect casts. Such rock occurs at the Linzee and other shafts about Carthage; also in the Kobinoor and in the Gray mines near Joplin and at Belleville.

Dolomite.—Under this heading we do not refer to the beds of magnesian limestone of the Ozark stage, nor to crystals, which are only of mineralogic interest. In southwestern Missouri, particularly in Jasper and Newton counties, are irregular deposits of dolomite immediately associated with the ore bodies. They are composed of a dense mass of white or drab dolomite crystals. These sometimes make a compact rock, sometimes they are incoherent and soft like sand, and can be dug with a shovel. This dolomite frequently occurs in small patches, scattered through the other gangue materials of the ore body, or even diffused in crystals; sometimes it is in large bodies, through which drifts are driven for hundreds of feet. It is generally contiguous to the limestone wall rocks, and appears to grade into the latter. Blocks of limestone are often found covered with a shell of such dolomite, evidently formed by the action of solutions containing magnesia, upon the limestone.

Barite.—Barite occurs as a gangue material, almost exclusively in the Southeastern and Southwestern districts. It will be quite fully described under the head of associated minerals, and we, hence, omit further reference to it here.

The Minerals of the Ore Deposits.—The minerals of the ore deposits we divide into: 1) lead and zinc compounds; and, 2) accessory minerals.

The principal zinc compound is the sulphide, sphalerite; important also are the decomposition products, the hydrosilicate, calamine, and the carbonate, smithsonite; these two are classed indiscriminately as "silicate" in the trade. Of rare occurrence is the hydrated carbonate, hydrozincite; no occurrence of the anhydrous silicate, willemite, has been noted.

Galenite is at present almost the only commercially important lead ore. In earlier days, more of the carbonate, cerussite (called dry bone), was found and utilized, but the quantity now mined is insignificant. Some of the sulphate, anglesite, and of the phosphate, pyromorphite, occur, but they are comparatively rare and not commercially important.

The principal accessory minerals are calcite (abundant in the southwest), barite (abundant in the southeast), dolomite, pyrite, marcasite, chalcyporite, quartz, bitumen, limonite, malachite and azurite.

Though all of these minerals are found in the Southeastern and Central districts, they are most abundant and in most varied associa-

tion in the Southwestern district. This is a rich field for the mineralogist, and contains a wealth of material of crystallographic interest.

Sphalerite (zinc sulphide, ZnS).—Sphalerite, or blende, locally known as "jack," occurs in great abundance and purity in Jasper and Newton counties. It is also found in Lawrence and Dade, and some little in Jefferson, Washington and Morgan counties—in the latter, associated with barite.

In color, it varies from yellow to black; generally it is a dark red or brown, with a resinous lustre on fresh fracture. At times it is of a steel blue color, resembling galenite. The ore of the Wentworth mine is notably light colored and pure; some of the Granby ore is also. The colors are due to the impurities, especially iron and cadmium; the black color is probably often due to bitumen.

Sphalerite occurs in massive and granular forms and in crystals. The latter vary ordinarily from the size of a pin's head to that of a walnut. One almost perfect octahedron, in the possession of Mr. Will Picher, of Joplin, is nearly four inches in diameter. The crystals are generally tetrahedral, with highly lustrous surfaces; they are very complex and distorted, and polysynthetic laminae are often developed from twining. Fine crystals are found at Martin's coal-pit, near Versailles, in Morgan county, having a particularly bright lustre, and such are often found in these outlying coal pockets. An amorphous sulphide of zinc occurs at Galena, Kansas, and near Joplin. This is evidently deposited from solution along with tallow clays. Rarely it is found in the form of stalactites; specimens of such from the Oswego mines at Joplin were presented the writer by Mr. J. R. Holibaugh.

Sphalerite occurs distributed through clay, dolomite or secondary chert gangues in varying proportions. It also incrusts cavities, and crystals are attached to chert slabs. One specimen from the Eagle mine at Joplin, as described by Dr. Hovey [112], weighed 790 pounds, and consisted of a huge aggregate of crystals 4 to 6 inches in diameter. The crystals were covered with doubly terminated scalenohedra of calcite, like rice grains, with an occasional crystal of galenite.

Sphalerite is found deposited upon crystals of dolomite. Red-colored crystals were seen on galenite; calcite and pyrite or marcasite are deposited on sphalerite. On one specimen from southeastern Missouri, in the possession of Mr. Wm. M. Chanvenet, of St. Louis, sphalerite is deposited on pyrite. It sometimes replaces fossils. A replaced *Zaphrentis* is in the Survey collection. Mr. W. C. Wetherell, of Joplin,

has a cast of a crinoid composed of sphalerite, the mineral having apparently filled the central cavity of the stem. On many crystals, a greenish yellow coating of the cadmium sulphide, greenockite, is found.

By some, the bright red or ruby-colored sphalerite has been considered of secondary deposition. Some facts indicate this, but others are opposed to it. Sphalerites of different colors are found deposited on galena.

The following table of analyses will convey an idea of the composition of Missouri sphalerites. Additional analyses were contemplated, but time and means did not allow of their being made.

TABLE OF ANALYSES OF MISSOURI SPHALERITES.

Location.	Zinc.	Iron.	Cad- min.	Anti- mony.	Sul- phur.	Copper	Silica	Analyst.
1. Jasper county—								
Joplin, Porter m.	65.92	0.32	0.509	.....	.....	.....	0.25	Chauvenet. Rept. 1873, p. 392
2.	61.963	0.588	0.000	0.000	*	0.000	*	Williams. Rept. 1876,* p. 106.
3. Joplin, Leadville	64.87	0.37	0.723	.....	.....	.....	1.41	Chauvenet Rept. 1873.
4. Newton county—								
Granby, Bellewm	64.67	0.53	.....	.....	.....	.....	2.05	Chauvenet. Rept. 1873.
Granby	61.934	0.788	Tr.	0.02	31.269	0.043	2.552	Williams Rept. 1876.

*Not determined.

Calamine (zinc silicate, $H_2 Zn_2 SiO_5$).—This compound of zinc is locally known as “silicate,” and is not distinguished from the carbonate, smithsonite, in the trade. It is especially abundant at Granby, in Newton county, but also occurs in quantity at Aurora, and is generally found in small amounts at other points in the southwest. In the southeast it is of comparatively rare occurrence; specimens of clear white crystals, from the Valle mines, are in the Washington University collection.

The color is generally a light yellow to white, and transparent, though it is sometimes stained dark. Occasionally it is of a bright yellow, from admixture of cadmium.

It occurs usually in botryoidal or tabular forms, often forming incrustations, with drusy surfaces of closely twinned crystals. A beautiful variety, found at Aurora, consists of sheaf-like aggregates of tabular crystals, gathered in rosettes, which have a peculiar, silk-like

Fig 1

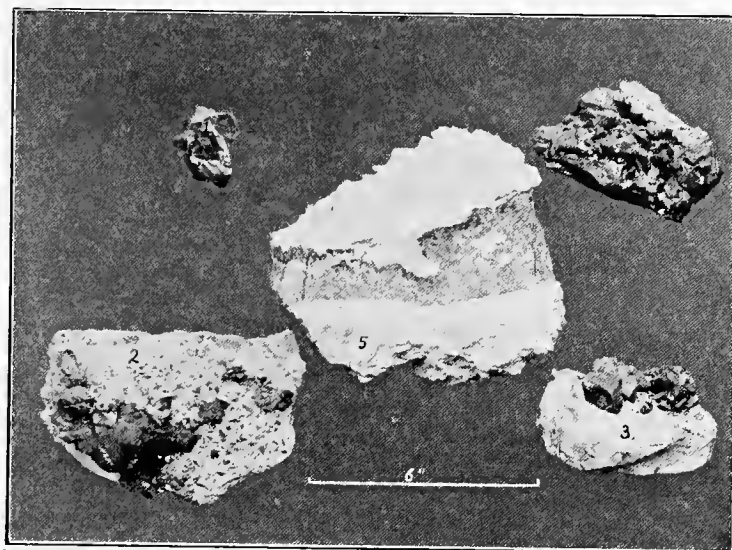
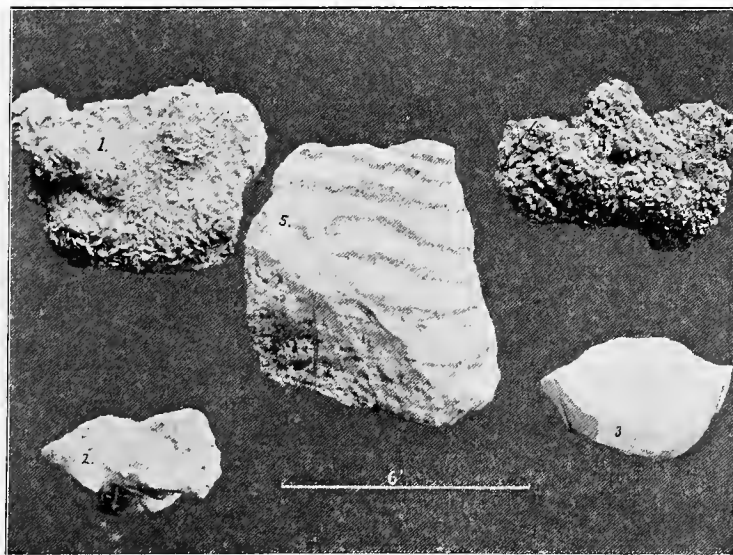


Fig 2



BLENDES AND DOLOMITES.

FIG. 1. NOS. 1 AND 4 — BLENDE, CRYSTALS.

No. 2 — BLENDE ON DOLOMITE.

FIG. 2. NOS. 1 AND 2 — DOLOMITE, CRYSTALLIZED.

No. 5 — BLENDE BANDS IN DOLOMITE.

No. 3 — BLENDE ON CHERT.

5 — BLENDE AND GALENA BETWEEN CHERT

No. 4 — QUARTZ CRYSTALS ON CHERT.

4 — MASS OF MARCASITE CRYSTALS.

FIG. 1.

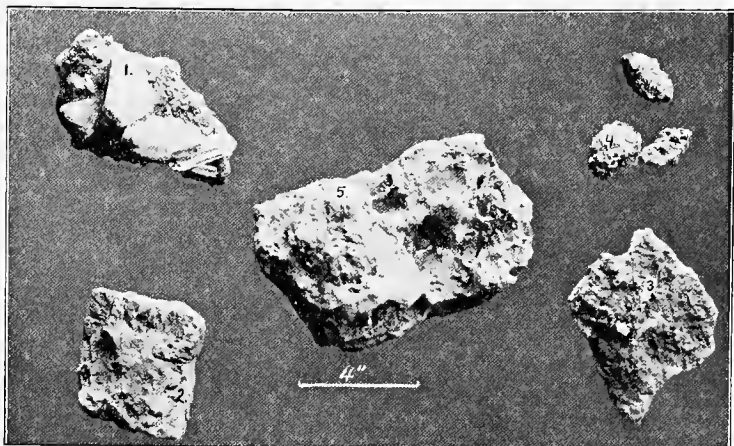
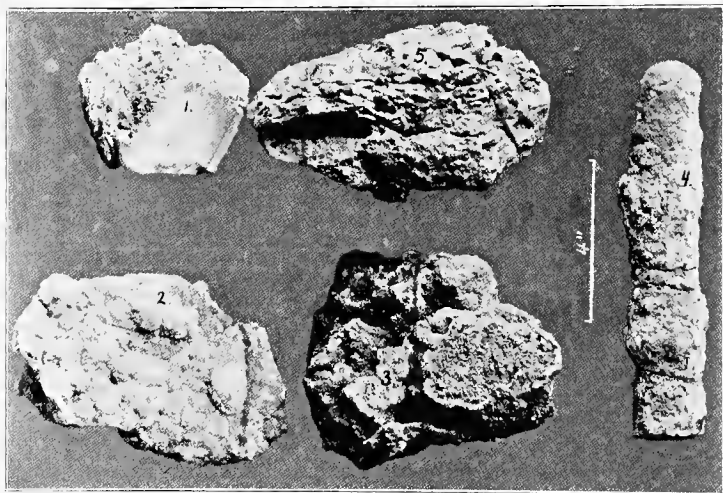


FIG. 2.



SMITHSONITES, CALAMINES AND CERUSSITES.

- FIG. 1. No. 1 — TABULAR CRYSTALS OF GALENA.
 No. 2 — GALENA COATED WITH CERUSSITE.
 NOS. 3 AND 5 — MASSIVE CERUSSITE.

- FIG. 2. No. 1 — CALAMINE COATING CALCITE.
 No. 2 — CALAMINE, CRYSTALLINE COATING.
 No. 3 — SMITHSONITE, MASSIVE.
 No. 4 — STALACTITE OF SMITHSONITE.
 No. 5 — LAMINATED SMITHSONITE.

sheen. Stalactites of calamine have been found occasionally. One from Granby is in the possession of Mr. J. A. Reeves, of Joplin. It is sometimes found in amorphous form as tallow clay.

Calamine generally incrusts sphalerite, and plainly results from its decomposition. It is often found coating calcite, and is evidently later deposited. Hollow pseudomorphs are thus formed, sometimes lined with minute crystals. It is sometimes found on dolomite. One interesting specimen from Granby shows well-formed, isolated crystals of calamine attached to the surface of sphalerite.

In the following table are a few analyses of this mineral:

TABLE OF ANALYSES OF MISSOURI CALAMINES.

Location.	Zinc oxide.	Silica.	Ferric oxide.	Calcic oxide.	Water.	Analyst.
1 Newton county—						
Granby.....	66.813	25.489	1.114	Tr.	7.502	Winters, Rept. 1876, p. 24...
2 " Village Digs....	63.05	27.51	1.22	1.21	7.10	Chauvenet, Rept. 1873, p. 393
3 " Frazier.....	66.37	26.88	0.65	Tr.	6.46	" " "
4 " ".....	67.15	23.32	0.61	.....	8.59	" " "

Smithsonite (zinc carbonate, ZnCO_3).—This mineral, together with calamine, is known as silicate in the state. The name dry bone, applied in Wisconsin, is not in vogue here. It is the principal ore of zinc at the Valle mines, in the Southeastern district; it is also found in quantity at Granby, in the southwest, and in small amounts at Aurora and in Dade and Wright counties and elsewhere.

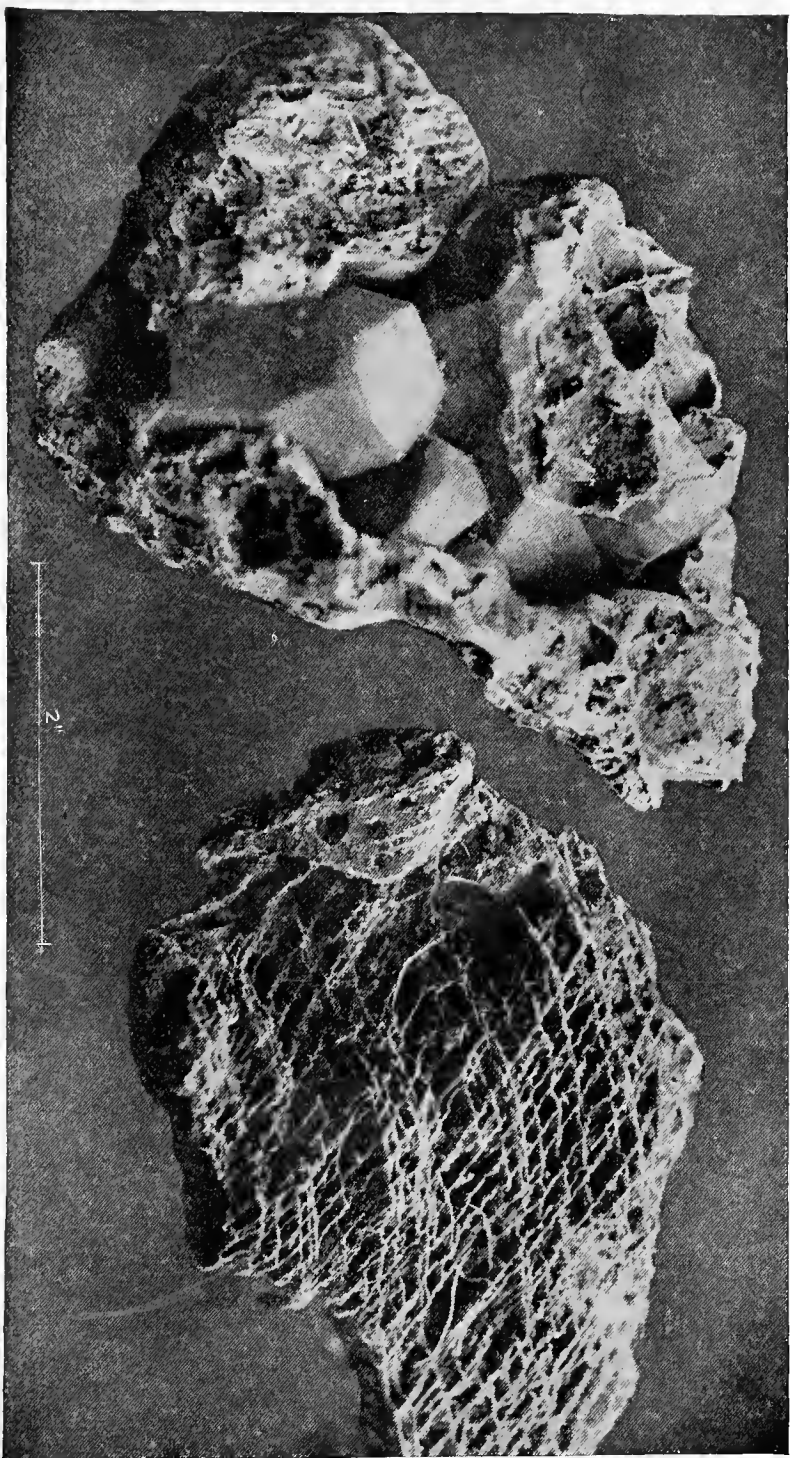
The color is generally a white, or light yellow, sometimes bright yellow from cadmium, and sometimes dark from other impurities. It occurs usually in botryoidal masses or in distinct crystalline layers. The luster on fresh fracture is opalescent, not so glistening as that of calamine, but often difficult to distinguish from it. It is often in a rough, porous condition, like the pithy part of a bone, and hence its name of dry bone. It frequently coats sphalerite, often replaces calcite and is pseudomorphous after the latter. Fine specimens of such pseudomorphous are in the possession of Mr. John Kingston, superintendent of the Granby mines. It is often found stalactitic, and a specimen of such is illustrated in the opposite plate. It is sometimes massive and granular. Analyses are given given on the next page.

Hydro-zincite (hydrocarbonate of zinc, $\text{ZnCO}_3 + 2\text{Zn}(\text{OH})_2$?)—None of this mineral was found by the writer, but Schmidt describes it as

TABLE OF ANALYSES OF MISSOURI SMITHSONITES

Number	Locality	Zinc oxide	Carbon dioxide	Ferrous oxide	Ferric oxide	Alumina	Cupric oxide	Manganous oxide	Lime	Magnesia	Sulphur	Water	Insoluble residue	Total	Analyst	Reference and remarks
1	Dade county— Corry mines	54.84	31.69	1.20	5.62		...	...	0.45	0.41	...	0.16	7.33	99.77	C. P. Williams.	Rept 1877.....
2	"	59.50	36.33	2.51	1.06		...	...	0.85	0.21	...	...	0.48	100.29	"	"
3	"	57.31	34.29	3.84	1.32		...	0.07	0.60	0.41	...	0.03	2.90	99.77	"	"
4	New mines	59.09	...	...	3.23		...	...	1.20	0.28	...	...	...	...	"	Manuscript notes
5	Old mines	57.88	34.34	0.84	4.96		...	0.22	0.83	0.85	...	...	...	99.92	"	"
6	Burnside	40.34	21.24	...	...		23.12	...	1.88	1.02	...	7.58	0.28	100.16	"	"
7	Newton county— Granby	63.02	34.58	...	1.21		...	...	...	...	...	...	1.22	100.03	R. Chauvenet..	Rept 1873, p. 394
8	Washington county— Hopewell	53.937	24.302	1.039	4.263	0.632	0.052	...	2.393	0.546	0.242	2.414	8.510	*98.733	C. P. Williams.	Trans. A. I. M. E., vol. V, p. 426.

* Also a trace of lead oxide; .173 per cent cadmium oxide and .170 per cent antimony trioxide.



PSEUDOMORPHS OF SMITHSONITE AFTER CALCITE.

FIG. 1

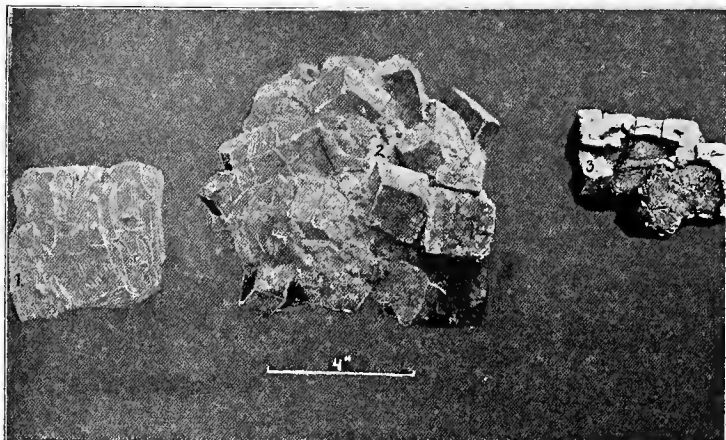
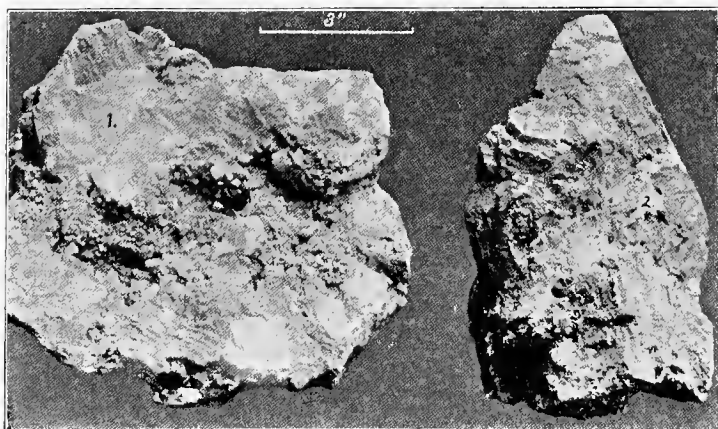


FIG. 2.



GALENA, CERUSSITE AND ANGLESITE.

FIG. 1. Nos. 1 and 3 — GALENA, DISTORTED COMPOUND CRYSTALS.
No. 2 — GALENA, AGGREGATE OF CUBICAL CRYSTALS.

FIG. 2. No. 1 — CERUSSITE CRYSTALS IN CAVITY OF MASSIVE GALENA.
No. 2 — ANGLESITE CRYSTALS IN CAVITY OF MASSIVE GALENA.

occurring in the Crab Tree diggings at Granby, "closely surrounding and coating fibrous calamine, into which the mineral gradually passes" [32, p. 394]. Mr. Gage also records that he observed it at the Valle mines.

Galenite (lead sulphide, PbS).—This lead compound, known as "mineral," is the only abundant ore of lead. It is found in large quantities in all counties of the three districts. In the disseminated condition, impregnating limestone, it is confined to the Southeastern district, and this is by far the greatest lead producer. During the first years of work at Aurora, it was also very abundant. Almost invariably, in the Jasper county mines, it is found at the higher levels, above the zinc ores.

The color is always a blue or lead-gray, the luster a bright metallic one, when fresh and not covered with a thin coat of the carbonate, which gives it a white or ash-gray color.

It occurs massive, granular and in crystals. The crystals are often very large, 6 ins. or more in diameter, sometimes distorted. There are often large aggregates of such crystals, known as "cog mineral," attached to or twining with each other, fastened to rock surfaces. Aggregates of smaller crystals, known as "dice mineral," down to the size of a pin's head, also occur. The crystals are almost always cubes, often with octahedral faces developed at alternate corners, sometimes at all. The perfect octahedron is rarely if ever found. At Aurora, tabular crystals of galenite were found, illustrated in the opposite plate. These were the only specimens of the kind seen anywhere. The mineral occurs sometimes as a soft sand or almost impalpable black mud.

In the rock, galenite occurs sometimes in solid sheets or veins, and sometimes cements fragments of chert; the granular galena of the disseminated ores is composed largely of imperfectly formed crystals. When imbedded in calcite, barite, secondary chert, dolomite or other gangue, the crystals are well developed, and evidently were formed prior to the solidification of the enclosing matrix. At Bonne Terre, however, galenite is found deposited on calcite, which is of special interest as indicating the recent formation of the lead mineral. The crystal faces are often studded with minute, dull or lustrous cerussite crystals; sometimes with later-formed pyrite, marcasite or calcite crystals. It seems generally later formed than sphalerite, though crystals of the latter are sometimes on galenite. Crystals of galenite are frequently seen on dolomite.

TABLE OF ANALYSES OF MISSOURI GALENITES.

No.	Locality.	Antimony	Copper	Iron	Zinc	Nickel	Cobalt	Silver (oz. per ton).	Insoluble residue.	References.	Remarks.
1	Cole county.....	0.04178	Trace.	0 02310	0 00804	0 00755	.....	.....	.....	Williams Rept. 1876, p. 16...	Specimen of remarkable purity, Eagle furnace.
2	"	0 16545	0 15141	0 05040	1 26352	.....	.....	.....	.....	"	"
3	"	0 00475	0 01187	0 00880	0 00502	.....	.....	.....	.....	"	Pioneer furnace ore.
4	Camden county.....	0 00317	0 00798	0 07450	0 00268	.....	.....	.....	.....	"	"
5	Jasper county.....	0	.....	0 04500	0 91000	.....	.....	1.25	0 44000	Chanvagnet Rept. 1874, p. 389.	Temple diggings, Joplin.
6	"	0	.....	0 19600	0 78000	.....	.....	0.75	0 71000	"	Swindle
7	"	0	.....	0 19600	0 52000	.....	.....	.....	0.53000	"	Lower Valley diggings, Joplin.
8	"	0	.....	0 24000	0 91000	.....	.....	1.00	1 72000	"	Oronogo
9	"	0	.....	Trace	Trace	.....	.....	0.75	0 33000	"	Stevens diggings, Turkey creek.
10	"	0 07439	0 00478	0 02169	0 00888	0 06600	.....	.....	.....	Williams Rept. 1876, p. 16...	Black mineral, Joplin.
11	"	Trace	0	0 12010	0 14679	.....	.....	.....	.....	"	Bruch diggings, "
12	"	0	0	0 09240	0 10601	.....	.....	.....	.....	"	"
13	Jefferson county.....	0 01000	0 00900	0 11800	0 08400	.....	.....	.....	.....	"	Valle furnace; also a trace of arsenic.
14	"	0	0	0 05180	0 04360	Trace	Trace	.....	.....	"	Valle.
15	Madison county	Trace	0	2 52900	0 04000	0 21400	Trace	.....	.....	Williams Rept. 1876, p. 16...	Bluff diggings, Mine La Motte.
16	"	Trace	0 08000	1 95900	0	0 16800	0 35700	.....	.....	"	Bluff diggings, Mine La Motte, aludge.
17	"	Trace	0 10300	1 43500	Trace	0 21300	0 04260	.....	.....	"	Bluff diggings, Mine La Motte, headings.
18	Miller county	0	.....	0 24000	Trace	.....	.....	0	0 15000	Chanvagnet Rept. 1874, p. 507	Walker diggings.
19	Morgan county	0 04754	0	0 02940	Trace	.....	.....	.....	.....	Williams Rept. 1876, p. 16...	Star furnace.
20	"	Trace	0	0 02240	0 00372	.....	.....	.....	.....	"	Madole diggings.
21	"	0	.....	Trace	Trace	.....	.....	Trace	0.11	Chanvagnet Rept. 1874, p. 507	New Granby diggings.
22	"	0	.....	0 48000	0 94000	.....	.....	Trace	0.21	"	Holman diggings, Granby.
23	Newton county	0	.....	0 18000	0 12000	.....	.....	Trace	0.61	"	Trant diggings, "
24	"	0	.....	0 06000	0 12000	.....	.....	1.25	0.12	"	Village diggings, "
25	"	0	.....	0 08000	1 35554	.....	.....	1.00	0.05	"	Black mineral, "
26	"	0 00551	0 00239	0 08602	1 76554	.....	.....	.....	.....	Williams Rept. 1876, p. 16...	Holman diggings, "
27	"	0 02764	0 01677	0 03220	1 76558	.....	.....	.....	.....	"	Crystals, Richardson shaft.
28	"	0 32194	0 04232	0 02970	0 02011	Trace	.....	.....	.....	"	St. Joe mine, with visible mixture of chalcocypite.
29	Phelps county	0 00392	0 02151	0 02518	0 03915	.....	.....	.....	.....	"	St. Joe mine, aludge.
30	St. Francois county	0 00569	4 65570	8 13040	0 32550	.....	.....	.....	.....	"	Ferry furnace, near Potosi; also 69% of arsenic.
31	"	0	0 7980	2 24400	0 61100	0 137	.....	.....	.....	"	"
32	Washington county	0 03100	0 04100	0 01100	0 5400	.....	.....	.....	.....	"	"

Missouri galenites all contain small amounts of impurities, notably iron and zinc; copper, nickel and cobalt specially characterize the disseminated lead ores of the southeast. The opposite table shows the amounts of these impurities contained in ores from different mines.

All of the galenites of the state contain small quantities of silver, but, outside of those of the Einstein mines, which are in Archean granite, none are rich enough to be classed as argentiferous. The highest yield, to the writer's knowledge, from galenite in limestone, is between 10 and 20 ounces to the ton. This was obtained by Mr. Arthur Thatcher, of St. Louis, from specimens actually collected by him from the Peach Orchard mine, in southeastern Washington county (Sec. 22, T. 36 N., 2 E.). The owners of the mine claimed as high as 30 or 40 ounces. The deposit, as described by Mr. Thatcher, consisted of a vertical crevice, expanding in places to a width of about 1 ft., filled with

TABLE OF SILVER CONTENTS OF MISSOURI GALENITES.

Locality.	Ounces per ton.	Notes.
Mine La Motte.....	0.38 to 4.00.....	Range of 4 samples.....
Potosi	trace to 0.38.....	" " 2 "
Perry mine.....	0.29.....	" " 2 "
Granby mines	1.00 to 1.75.....	" " 4 "
Joplin mines.....	.75 to 1.25.....	" " 3 "
Oronogo mines.	1.00.....	" " 1 "
Jefferson county mines	0.75 to 3.75.....	" " 2 "
Franklin county mines.....	trace to 0.75.....	" " 4 "
Phelps county.....	0.29 to 1.25.....	" " 2 "
Maries county.....	1.25.....	.....
Miller.....	0.....	.....
Morgan	trace.....	.....
Pulaski	trace.....	.....
Wright	1.00.....	.....
Laclede?.....	1.00.....	.....
Linn Creek, Camden county.	trace.....	.....
Cole Camp, Benton county...	trace.....	.....

TABLE OF ANALYSES OF MISSOURI CERUSSITES.

No.	Locality.	Lead	Lead oxide	Carbon di-oxide....	Lead sulphide....	Ferric oxide	Alumina .	Zinc oxide	Antimony trioxide.	Arsenic trioxide.	Lime	Magnesia.	Silica.....	Analyst and Reference.	Remarks.
1	Greene county— Ash Grove	66.55	69.520	13.533	.....	1.272	3.586	0.006	0.0538	0.0135	Trace	Trace	9.167	C. P. Williams, Ms. notes	In addition were found NiO&CoO traces, P ₂ O ₅ .121 per ct., SO ₃ .341 per ct., and water 2.166 per ct.
2	Newton county— Granby ..	66.15	.....	.....	.....	1.51	.....	0.75	.....	.....	Pres't	.....	9.95	E. Chauvenet, Re- port 1873, p. 390	Flesh-red, massive dry bone.
3	"	66.15	.....	.....	.....	Pre-ent.	.....	.....	.....	.....	.....	.....	6.12	E. Chauvenet, Re- port 1873, p. 390	Reddish brown, massive dry bone.
4	"	72.86	.....	.....	.....	0.55	.....	.....	.....	.....	0.40	.....	0.36	E. Chauvenet, Re- port 1873, p. 390	Reddish brown, massive dry bone.
5	"	63.64	.....	.....	.....	3.11	.....	0.73	.....	.....	0.75	0.36	10.35	C. P. Williams, Rept. 1877, p. 20	Ashy, wool mineral.
6	"	.....	84.0770	.....	.....	0.4340	.....	2.0314	0.1095	Not det.	0.0600	.....	2.4604	C. P. Williams, Rept. 1877, p. 20	Also 6.2387 per ct. lead sulphide, and .0678 per ct. cupric oxide.
7	"	77.47	.....	.....	.....	0.65	.....	.....	.....	.....	0.15	0.17	0.21	C. P. Williams, Rept. 1877, p. 20	From a stalactite of cerussite. Also .107 per ct. of lead sulphate.

galenite and gangue. A good general idea of the silver contents of these ores may be obtained from the preceding table, compiled from results published in the reports of the State Geological Survey for the years 1855, 1873 and 1877.

The disseminated lead ores of the southeast, as at present mined, carry, on an average, from $\frac{1}{2}$ to 2 ounces of silver. Recently, purchasers and smelters of these ores have made an allowance, at market rates, for all silver contained over $\frac{1}{2}$ ounce. This increases the value of a carload of lead ore by \$12 or \$15.

Cerussite (lead carbonate, PbCO₃).—This is known as "dry bone" and "ash mineral." It is found in all of the districts, mostly near the surface, but is nowhere abundant now. It was formerly mined in quantity at Granby. Recently, quite a large body was found near Spring City, south of Joplin.

The commercial cerussite occurs in massive form, somewhat cellular, and of dull yellow, earthy color. At Galena, Kansas, specimens were obtained of coarse, granular texture, consisting of a mass of intersecting, imperfect crystals, lustrous on fresh fracture. It is often seen as an earthy, white coating on galenite; it frequently studs the surfaces and lines cavities of galenite with minute prismatic crystals. In one fine specimen from the Palmer mine, stellite groups of twinned tabular crys-

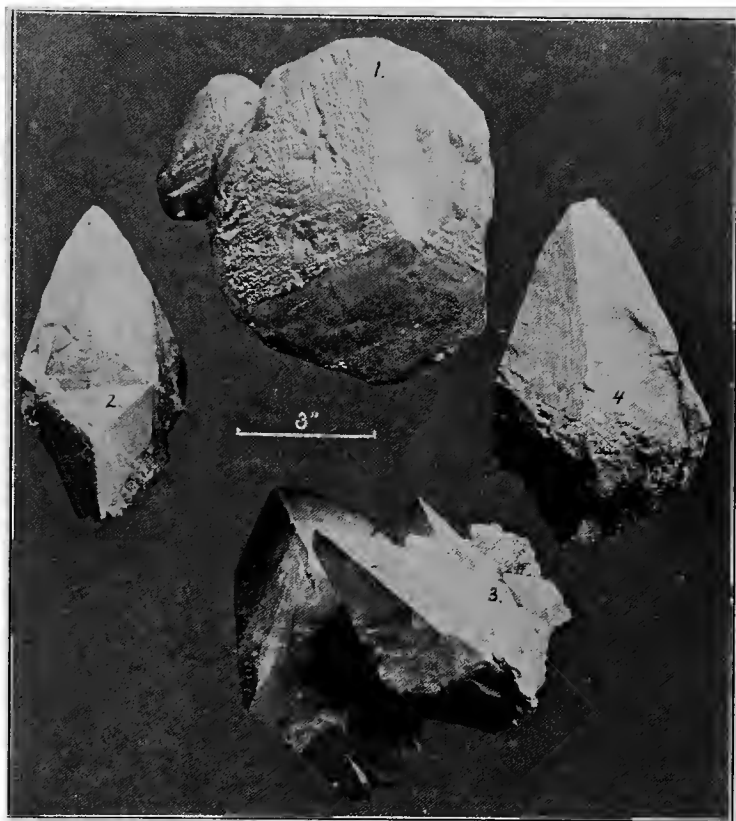
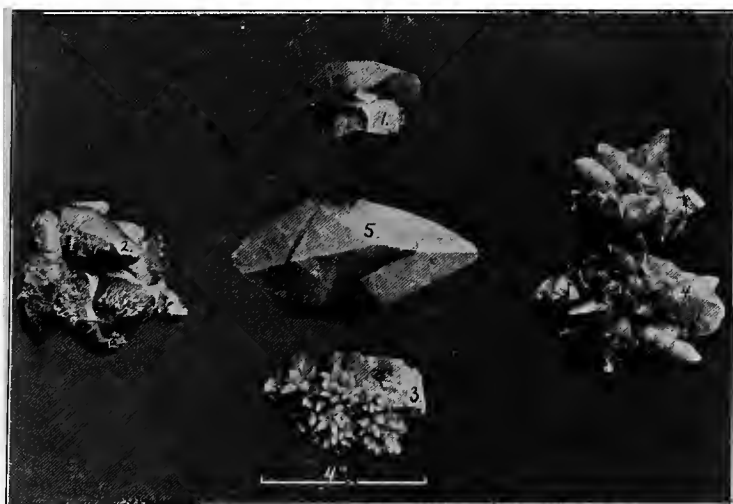


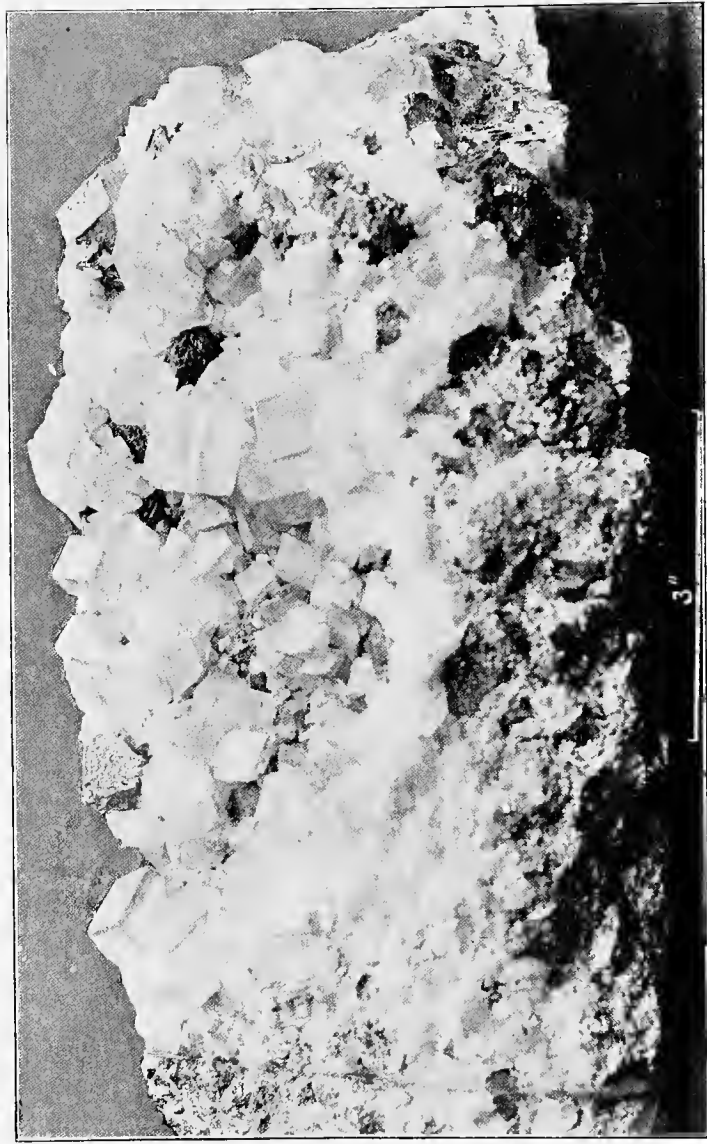
FIG. 2



CALCITES.

FIG. 1. No. 1 — RHOMBOHEDRAL CRYSTAL.
Nos. 2, 3 AND 4 — SCALENOHEDRAL CRYSTALS.

FIG. 2. No. 1 — SCALENOHEDRON ON GALENA.
Nos. 2 AND 4 — ROUNDED SCALENOHEDRA.
No. 3 — ROSETTE OF SCALENOHEDRA FROM MARBLE CAVE, STONE CO.
No. 5 — DOUBLY TERMINATED SCALENOHEDRAL CRYSTAL.



RHOMBOHEDRAL CALCITE, FROM AURORA.

tals almost cover the interior of a large cavity in galena. Similar occurrences are reported at the Valle and Mine La Motte mines by Mr. Gage. Schmidt refers to occurrences [32, p. 388] at Granby and Oronogo. At the latter place, he describes excellent illustrations of the formations of this mineral by the decomposition of galenite. The composition of a few Missouri cerussites is given in the opposite table.

Anglesite (lead sulphate, Pb SO_4).—This is a comparatively rare mineral, of no commercial importance. It occurs in fine tabular crystals on galenite, and also lining cavities of the same. One specimen from the Palmer mine shows fine bunches of tabular and fibrous crystals lining a central cavity in a mass of galena.

Pyromorphite (lead phosphate, $\text{Pb}_3 \text{P}_2 \text{O}_8 + \frac{1}{2} \text{Pb Cl}_2$).—This is of rare occurrence. It is found coating and incrusting cavities of galena crystals, in prismatic groups, or in rounded, barrel-shaped rods. Schmidt describes it at Granby as occurring massive and amorphous and in rounded pieces, and also as a shaly coating, generally on cerussite [32, p. 390].

Leadhillite (the hydrated sulphato-carbonate of lead, $\text{PbSO}_4 \cdot 2\text{Pb CO}_3 \cdot \text{Pb(OH)}_2$).—This mineral has recently been determined by L. V. Pirsson and H. L. Wells [256], mingled with cerussite from Granby. This is, therefore, a new locality of the occurrence of this rare mineral, and the only one so far known in the state. The leadhillite occurs implanted upon the masses and crusts of cerussite in well-defined crystals, or in groups studding cavernous interiors.

Calcite (calcium carbonate, Ca CO_3).—This mineral, known as "tiff" or "glass tiff," is one of the most interesting found in the ore deposits, and occurs in a great variety of forms. It is abundant in the southwest, about Joplin, Granby and Aurora. It is also found in fine crystals in the southeast, at Mine La Motte, Bonne Terre, and in Jefferson and Washington counties.

The color is generally yellow and sub-transparent, sometimes dark, sometimes milky white, and translucent. Occasionally, pure white, transparent crystals have been found in St. Francis county.

The crystals are generally scalenohedra, often doubly terminated; sometimes rhombohedra are found, especially at Aurora. The scalenohedra reach great size, sometimes two feet in length; they are also very minute. About Joplin, calcite crystals with peculiarly curved faces are abundant; but such are also found at Bonne Terre and elsewhere in smaller number. These are of great crystallographic interest,

and deserve further study. They seem to be peculiar to Missouri—at least in quantity.

Calcites are generally found imbedded in the clay of ore deposits. They also line cavities. They are normally later formed than other minerals, and are deposited on them, excepting pyrite or marcasite, which is frequently found on calcite. Sometimes, a secondary enlargement of calcite is shown by pyrite crystals on the surfaces of crystal ghosts in the interior. Such were observed at Bonne Terre. At Aurora, calamine frequently coats the surfaces of calcite crystals. About Potosi, calcites are often found on barite crystals.

From Ste. Genevieve county, a beautiful collection was exhibited at the World's Fair of large scalenohedra coated with a secondary growth of smaller crystals. In Stone county, beautiful aggregates of small scalenohedra of pinkish color, arranged in rosettes, are found in Marble cave. Crystal cave, Joplin, to be described later, has a wonderful display of mammoth crystals.

TABLE OF ANALYSES OF MISSOURI CALCITES.

County.	Calcium carbonate.	Magnesium carbonate.	Ferrous carbonate.	Insoluble.	Analyst.	Reference.
1. Jefferson	98.680	0.945	0.047	.0	Garvens	Rep. '77, p.21
2. Newton.	97.962	1 853	0.253	.0	.....	"

Barite (barium sulphate, Ba SO_4).—This mineral is known variously as "tiff," "heavy tiff" and "ball tiff." It is confined almost exclusively to the Southeastern and Central districts, though small quantities have also been found in the southwest, in mines at Joplin, Seneca, and at other points.

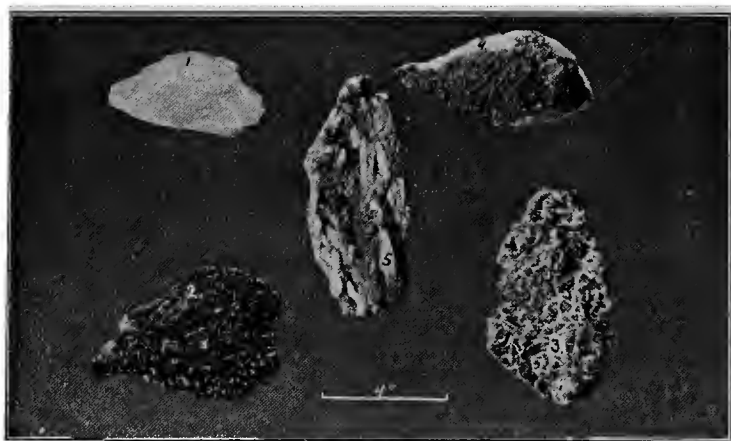
The texture is generally massive or granular; it is also found in reticulated layers or in tabular crystals of milky white, blue and yellow tints. The color of the massive varieties is white or yellow.

Barite replaces limestone, and is also pseudomorphous after calcite. In Pettis county, fossils of the Burlington limestone are replaced by barite. In this same county, fine tabular crystals are found with peculiarly clouded and banded edges, the clouding being apparently caused by an admixture of sulphate and of small amounts of calcium and ammonium sulphates [143—p. 495]. In Washington county, barite occurs in peculiarly cone-shaped masses, which have rough, ridged surfaces,

FIG. 1.



FIG. 2.



BARITES.

- FIG. 1. NOS. 1 AND 5 — TABULAR CRYSTALS WITH WHITE OPAQUE BANDING AT EDGES.
 NOS. 2 AND 4 — SINGLE TABULAR CRYSTALS.
 NO. 3 — MASS OF PRISMATIC CRYSTALS.
 NO. 6 — MASS OF TABULAR CRYSTALS.
- FIG. 2. NO. 1 — WHITE INTERIOR OF MASSIVE CONE.
 NOS. 2 AND 4 — EXTERIOR OF MASSIVE CONE.
 NO. 3 — RETICULATED MASS.
 NO. 5 — MASS OF TABULAR BARITE.

such as is illustrated in the opposite plate. It occurs most abundantly massive, filling veins and mixed with other minerals, also in lenticular sheets, forming large bodies, with red clay between the layers, as if the barite had replaced a series of thin beds of limestone.

Barite seems to be generally of later formation than galena or blende, but this is doubtful in cases. It was probably often simultaneously deposited.

Dolomite (carbonate of magnesium and calcium, CaMgCO_3).—This is commonly known as “spar.” It is very abundant in the southwest, but not so in the southeast. It occurs in masses, consisting of a granular or dense aggregate of minute crystals. This is sometimes soft and incoherent, and is called sand. The color varies from white to dark gray.

It crystallizes in small, tubular, rhombohedral crystals, with curved faces, in dense aggregates. These coat surfaces or line small cavities. The crystals are often of a white to pinkish color, with a delicate pearly luster. Dolomite is undoubtedly an early formed mineral in the deposits of the southwest, preceding both blende and galena.

Pyrite and Marcasite (iron sulphide, Fe S_2).—These are familiarly known as “mundic.” Pyrite, in isometric crystals, is comparatively rare. Marcasite is abundant, especially in the southwest. It occurs generally in globular and reniform masses, with roughened surfaces; also tabular and in stalactites with radiated structure. The crystals are often in beautiful aggregates, with curved faces, displaying iridescent colors. It occurs attached to chert and other rocks, and to the surfaces of almost all of the minerals of the ore deposits. It is also found in large irregular masses in shales and clays. It is often associated with bitumen. This is a late deposited mineral, and is probably still forming.

Chalcopyrite is also quite common. Interesting specimens from the North Star and Victor mines,

TABLE OF ANALYSES OF MISSOURI BARITES.

Locality.	Barium sulphate.	Strontium sulphate.	Calcium sulphate.	Ammonium sulphate.	Ferric oxide.	Silica.	Water.	Total.	Analyst.	Reference.
1 Jefferson county .	98.194	0.500	Trace.	.....	0.176	0.898	0.454	100.222	W. C. Minger.	Rept. 1877, p. 28.
2 “ “ “ “	96.791	1.436	0.325	.....	0.191	1.200	0.148	100.091	J. D. Greason.	“ “ “ “ “ “ “ “ “ “
3 Pettis county.	87.200	10.900	0.200	0.2	2.400	.....	.....	100.900	Indeking & Wheeler.	Am. Jour. Sci., vol. xlii, p. 439.

described by Dr. Hovey [122, p. 27], show numerous small tetrahedra on sphalerite crystals, arranged in parallel positions on the same surfaces.

Quartz (oxide of silicon, SiO_2).—This is a comparatively rare mineral in crystallized form. It also seems to be of late deposition. It is found coating chert fragments, sometimes in very minute crystals, showing merely as a glistening surface. Sometimes these crystals are of good size. Specimens from Washington county show galenite and cerussite, both coated with quartz. In the form of drusy quartz and chert, it is quite abundant in southwestern Missouri, as has already been stated.

Bitumen.—This is found principally in the breccia of the ore bodies of the Southwestern district. It also occurs there in cavities of the country rock. Sometimes, the rock or gangue is completely saturated with it, and the quantity is considerable. It is generally a brownish red or black fluid, which hardens on exposure.

Minor Minerals.—Malchite, azurite and limonite are minerals of subordinate interest here. The first two are occasionally found, resulting from decomposition of chalcopyrite. The last is quite abundant in the ore bodies in some of the less pure forms, often derived from the decomposition of marcasite.

Paragenesis of Minerals.—This subject has been quite fully discussed by Schmidt. As to the originally formed minerals of the southwest, he notes the following succession: galena, blende, dolomite, calcite, pyrite. In the southeast, the succession was: blende, galena, barite, pyrite, calcite.

So far as the writer's observations have gone, the succession seems to be generally: dolomite, blende, galena, barite, calcite, pyrite. This order is not invariable, but is the rule. Dolomite appears, however, to be constantly of prior formation. Decomposition products are naturally of any age subsequent to the formation of the original mineral.

THE STRUCTURE OF THE ORE BODIES.

The prevailing structures are the brecciated and the granular or crystallized; the dense and the banded are, however, also found.

The brecciated structure characterizes the southwestern deposits, as has already been said. Details of many such ore bodies are given in the descriptions of the mines about Joplin. The main part of such

ore bodies consists of blocks of chert and other rocks, imbedded in a matrix of clay, shale and secondary chert, through which the metalliferous and other minerals are diffused. Not all of such a breccia of any one ore body is metalliferous, and many such masses of breccia contain no ore. Strictly speaking, perhaps, only such can be classed as ore bodies as contain ore. Sometimes, the brecciated condition passes by gradations into unaltered country rock; sometimes the line of separation is sharp. Breccia filling vertical crevices very often contains comparatively few fragments, and the filling is mostly clay matrix. Such are common in Jefferson and Washington counties of the southeast. Other vertical crevices are compactly filled with a solid breccia. In the Central district, the circular or chimney deposits have a brecciated structure.

The granular or crystallized structure characterizes the great deposits of disseminated ore in the Southeastern district. These are made up of an aggregate of grains, and often of well-defined crystals of galena and dolomite. Some crevice or vein deposits, such as those at Mansfield, Wright county, have also a granular structure, passing into the brecciated. The Pierson creek ore of Greene county may also be classed as granular. Portions of the brecciated mass of the southwest are sometimes granular, especially those composed largely of dolomite.

The dense structure is, strictly speaking, applicable only to those vein fillings of the Southeastern and Central districts, which are composed entirely of one mineral, generally galena. They are usually very narrow or thin. It is applicable also to those composed of massive barite. The class is not an important one.

The banded structure is rare. True ribboned veins are not found. Barite and galena occur in the flat and interbedded deposits of the southeast, sometimes in layers; but these are almost the only instances.

THE MODE OF FORMATION OF THE ORE BODIES.

For the purposes of this discussion, we shall consider the deposits in the following order:

- 1) Deposits filling crevices, chambers or caverns, such as occur in all three districts.
- 2) Brecciated deposits of the Southwestern and Central districts.
- 3) Deposits impregnating the country rock of the Southeastern district.

The consideration of the first class resolves itself into: a) how were variously shaped cavities formed? and b) how was the filling effected? These questions answered, with the second class the mode of formation of the breccia is the principal problem which presents itself. With the third it is, then, alone, how were the metalliferous minerals introduced?

The Formation of the Cavities.—The crevices containing ores are principally of two kinds: 1) those transverse to the strata, and vertical or approximately so; 2), those between strata and horizontal. The formation of both of these is well understood, and can be explained in a few words.

From what has already been said concerning the geologic history and structure of southern Missouri, it is plain that this has been an area of frequent crustal movements; several uplifts and depressions have succeeded each other. These movements produced strains of various kinds, resulting in fracturing, faulting, and some flexing. Faults necessarily produce vertical openings in rocks; but, in addition, the rocks have been fractured without faulting along many lines, forming joint planes. Further, they are massive sediments, which, covered since their original deposition, have probably shrunk and have suffered various chemical changes, resulting in similar fractures and openings. Such structures, as Crosby has recently pointed out [255], are probably developed very early in the history of the rocks.

These rocks, in the intervals between different submergences, and especially since the last great Carboniferous uplift, have been long exposed at the surface, and have been subjected to energetic action of atmospheric waters and other surface agents of decay. These waters, sinking into the ground, naturally chose the openings along faults and joints for their lines of flow. Charged with carbonic, and probably organic acids also, they exerted a corroding action on the limestone wall rocks, and soon widened the spaces between the planes of fracture. Where the rocks were more soluble, or the agents more aggressive, the action was quicker, and hence such irregularities as chambers or caverns. In some cases, irregularities of fault-plane surfaces, or brecciation caused by movements, doubtless supplemented this. Without proceeding to further detail with such well-known processes, it will be readily understood how these crevices and associated cavities have originated. The fact, well illustrated at Bonne Terre, that crevices diminish in width, and even die out with depth, is proof of their for-

mation largely through surface agents. The character of the filling of many is further evidence, as will appear later.

As regards horizontal or interbedded cavities, whether these be mere narrow crevices or high and wide chambers, their origin in limestones is exactly the same as with the vertical openings, excepting in the localizing causes. Here, movements of the rocks have had probably less influence, though a horizontal slipping of the strata may have occurred at places (as a result of shrinkage or plication) producing brecciation and crushing of the rocks. Generally, however, a difference in composition has been the localizing cause. The downward flow of surface waters along vertical crevices may be arrested by a comparatively impervious stratum, or by some obstruction just at such a stratum; the waters would then seek their way along the top of this bed dissolving the rocks above it. Or, because of differences in composition, texture or structure, one bed or portions of a bed may be more pervious or soluble than another, causing waters to flow along it and to corrode adjacent walls. This is the familiar process by which intricate passages and chambers of caves in limestones are formed. The same has produced the cavities in which the flat or horizontal deposits of southeastern Missouri occur.

The Filling of the Cavities.—We have seen that the cavities thus formed are filled with different materials. These we have divided into gangues and minerals. The gangues are principally clays, and fragments or blocks of country rock. The minerals we have divided into lead and zinc compounds and accessory minerals.

The fragments of the country rock are readily seen to be derived from the walls of the cavities. Generally they are such as are found in the immediately adjacent walls. Sometimes they may have been transported from more or less remote portions of the cavity. They are never foreign to the country. In the process of solution and decay of walls not entirely homogeneous, it is natural that more resistant portions should remain in place or fall to different positions in the cavity. Brecciation along planes of fracture and movement doubtless often supplements this.

The clays, which sometimes fill these cavities almost completely, cannot be explained in precisely the same way. The wall rocks contain such materials, it is true, but not in anything like a sufficient quantity for the filling to be merely residuary clay in place. The great bulk of these clays must have been transported. We refer them largely to

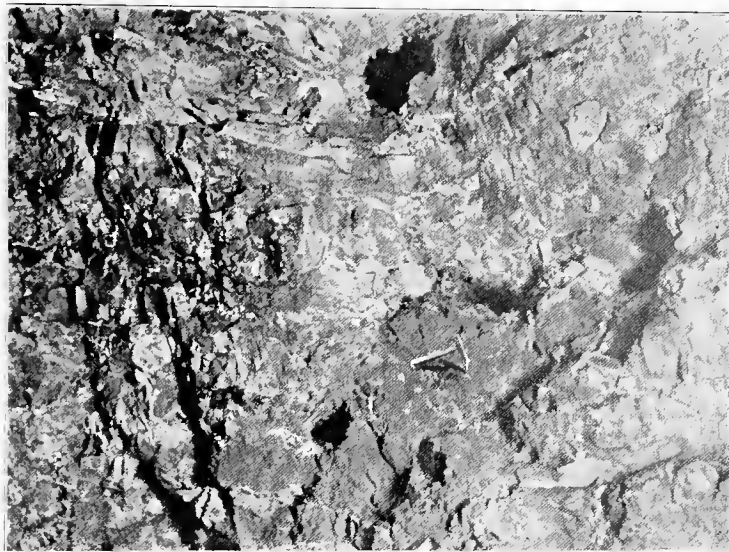
surface origin, and the transporting agent was water flowing in from the surface.

The decay of the rocks at the surface has been very great, not only during recent times, but also in past geologic epochs of emergence, and especially since the deposition of the Lower Carboniferous limestones. The corroded and pinnacled surfaces attest this. The great deposits of clay at present found, we can but regard as residuary from such decay. Surface waters would naturally transport the finer products of this decay into the crevices and caverns of the rocks, and often, when in volume, would doubtless carry coarse material and even rock fragments with them. A clogging of a cavity at any point would result in rapid filling. The animal remains found in the Wisconsin deposits were probably introduced in this way. During past epochs of submergence, great quantities of such surface residues must have been washed in. In some caverns, the assorting power of water is shown by a distinct stratification of the clays. They also often fill the space completely from top to bottom, reaching into all the irregularities, such as pockets and crevices, of the corroded roof. Only through introduction in a nearly liquid condition could such filling be effected.

In some cases, chemical deposition doubtless supplemented this. The very pure, plastic, tallow-like clays have all probably originated in this way. Gangues of crystalline limestone completely filling crevices have also been deposited from solution, as have also cherty or quartzite matrixes, which sometimes, though more rarely, occur in deposits of this class.

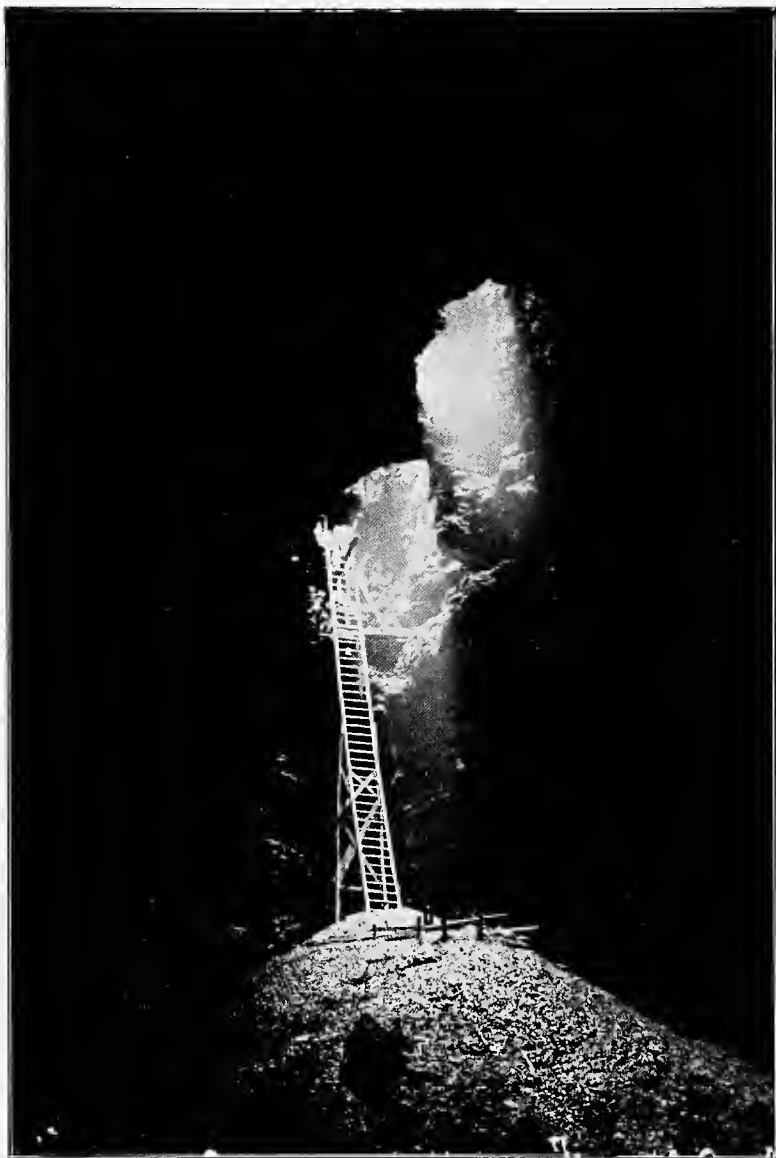
The substances in these deposits which we have classed as minerals, have all been deposited from solution; generally by chemical reaction, sometimes, possibly, by concentration and evaporation. These solutions have traversed the crevices and, on meeting with suitable reagents or suitable physical conditions, the various minerals have been deposited in familiar ways. Once the deposition of a mineral begun at any point, it continues, by reason of the law of affinity or segregation, governing the separation of minerals from solution. The question of the sources of these solutions or of the contained minerals, we will postpone consideration of till the final section of this chapter.

The Formation of the Breccia Deposits.—The breccia deposits of the southwest are the products of action on a larger scale of the same agents that have formed the deposits filling crevices and caverns. The



ORE BRECCIA OF SOUTHWESTERN MISSOURI.

From photographs by W. P. Jenney.



ENTRANCE TO MARBLE CAVE, STONE CO.

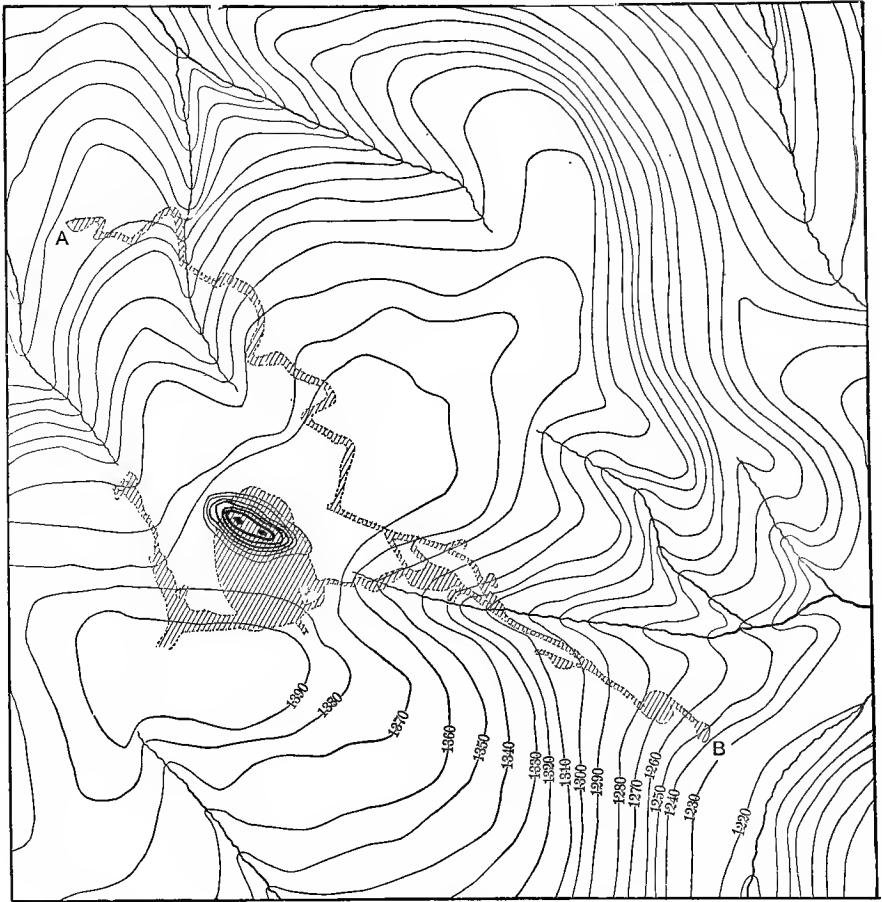
limestones have been dissolved by surface waters, and the breccias are but huge accumulations of residuary materials.

As is shown by the numerous sections of the rocks given on the preceding pages, we have in the southwest, to thicknesses of hundreds of feet, alternate layers of chert and limestone. These rocks have been affected by crustal movements, producing planes of jointage and fracture, like those found in other parts of the state. The limestones here are probably more soluble, the solvents have been stronger—especially during the early part of the Coal Measure epoch, when the district was on the margin of the swamps, and the waters were highly charged with carbonic and organic acids. The frequent alternation of these beds of limestone with impervious chert beds, intensified the action along certain planes. As a result, the limestones have been dissolved out through great thicknesses and over large areas. Their removal caused a settling of the ground, and a fracturing of the chert beds. The depressions thus produced caused additional influx of water, inducing further dissolving and removal of the limestone, and further settling and fracturing of the indestructible chert, until ultimately reduced to the condition of a breccia. Into these depressions, and thence to the subterranean cavities, surface waters naturally carried the finer residues of surface decay, such as clays and sands, and doubtless, often, dragged coarser materials, thus filling the smaller spaces. A submergence of this deeply corroded area, during the Coal Measure epoch, would bring more fine material into the interstices of the breccia, and would also give rise to the formation of overlying later deposits in the surface depressions. Thus have been formed the shales and coal pockets of this country, under and around which many of the so-called "circle deposits" of ore have been worked. Later subterranean solution would result in further settling under such pockets, causing the beds to assume steep dips, or even brecciating them and transporting the fragments to greater depths.

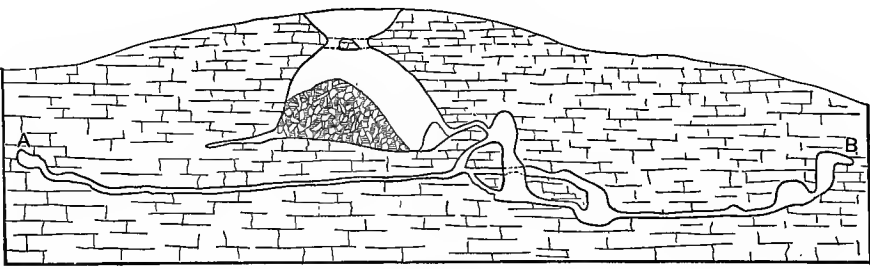
The minerals of these breccias have been introduced as have those in crevices and caverns—the nature of the mineral varying according to the physical or chemical conditions.

To be included under the head of breccias are, further, the fillings of those peculiar deposits of the Central district, known as "circles." These are well illustrated by the High Point mine in Moniteau county, Smith's mine in Cole county, the Conlogue mine in Miller county and the Rambo in Dallas county. They are essentially deposits filling wide

FIG. 115.



PLAN



PROJECTION

AMERICAN BANK NOTE CO., NEW YORK

MARBLE CAVE, STONE COUNTY.
Horizontal and Vertical Scale, 1 Inch=300 Ft.

circular cavities or chimneys 50 to 100 feet in diameter, which generally widen outlaterally with depth, down to certain limits, so that the space occupied within the surrounding walls has the shape of an inverted cone. The most natural explanation of these deposits is that they are fillings of caves which had vertical openings leading to the surface. On the opposite page we give, in evidence, a plan and cross-section of the well-known Marble cave in Stone county, made from actual surveys by Dr. E. O. Hovey and Mr. Robertson. The cross-section of the main cavern show that its shape is closely that of the later described circular deposits. We have the same conical shape with widening of the walls downward. In the center is a conical mass of debris, consisting of rock derived from the roof and surface. Around this is an annular space. If now, the outlet downward from this cave were closed, and waters carrying surface materials were introduced at the top, the whole space would become filled as are the circle deposits. The annular space about the central cone of debris would be, subsequently, the most ready course for solutions carrying metalliferous and other minerals. Thence, they would penetrate inward into the core of the breccia, and outward into the crevices of the wall rock. Hence we should expect the greatest concentration of these minerals in the annular space, as is the case with the circle deposits. At the bottom of the cavity is the floor of the cave, beyond which the ore would not extend, excepting along crevices. Such a floor is also found in the circle deposits where exploitation has proceeded far enough.

The Impregnated Deposits of the Southeast.—Concerning these deposits, we will only say that the minerals have been introduced into massive beds of magnesian limestone by solutions, and have replaced particles or grains of the rock by the process of metasomatic interchange. The reasons for this conclusion, and the origin of the solutions, we will consider under the next heading.

THE ORIGIN OF THE METALLIFEROUS AND OTHER MINERALS.

In what precedes, we have taken the introduction of the minerals in solution as for granted. This is so generally accepted by scientific men, regarding not only these, but the majority of other ore deposits also, that the assumption is warranted. Formerly, as we have already had occasion to allude to, other ideas were held, but they have been abandoned with the growth of knowledge concerning processes of nature. Among miners and laymen generally, however, there still lurks

a belief that volcanic action has been instrumental. They speak of the deposits as having been "thrown up"; of their having "burst through." Chimney-like cavities are regarded as the throats of such ejections; the disturbed and broken rocks associated with the deposits as evidence of very violent movements. For these reasons, a few words as to other suggested modes of introduction than by solution, will not be out of place here. Two such processes are the only ones worthy of consideration, *i. e.*: 1) ejection or injection in a molten condition; 2) introduction by hot vapors.

1. Opposed to the idea of an original molten condition is the fact that many of the minerals of these deposits are not fusible, or that they would be decomposed long before the requisite temperature was reached. The rocks, as well as the minerals associated with ore bodies, are not such as result from fusion. In many cases there are no openings, like dikes or necks, extending downward, through which masses of molten matter could have been injected. There is no evidence of volcanic action in the surrounding rocks, no metamorphosis, no great disturbance; no metamorphic minerals are found. These are, in general terms, the principal reasons opposed. The supposition is so palpably out of the question to those having any knowledge of the subject, that it seems unnecessary to add anything further.

2. The arguments against the introduction by heated vapors are much the same as those opposed to an original molten condition. It is true that some of the minerals of the ore-bodies, such as galena, and even blende, can be volatilized at high temperatures, but others can not be. The main objection is that the heat required, even for those that can be volatilized, is very intense. No reason or cause for such is discoverable in this region. There are no igneous rocks in proximity to the ore-bearing formations. The necessary heat would be so great as to have metamorphosed the limestones, shales and other country rocks, and to have produced metamorphic minerals.

In the nature of positive evidence of the introduction of minerals by solution, is the fact that the compounds of the metals and the other minerals are all soluble in solutions which ordinarily traverse rocks. Further, the openings and pores of the rocks are sufficient to have served as passages for such solutions. The crystalline forms in which the ores are found, the stalactities and incrustations, are mostly such as are peculiar to deposition from aqueous solutions. The explanation

is in harmony with the physical and chemical conditions of the surrounding rocks, and with the geological history of the region.

This conclusion being granted, we pass to the final and important question as to whence came the solutions and contained minerals? The principal hypotheses advanced are as follows:

1. Original or simultaneous deposition with the rocks, in a concentrated condition, from oceanic waters.

2. Derivation from great depths in solutions ascending through profound fissures, from which the minerals were deposited in cavities, or impregnated the rocks.

3. Original diffusion through the country rocks, and subsequent concentration by percolating waters, by the process known as lateral secretion.

4. Original diffusion through the country rocks and subsequent concentration through surface decomposition of the latter, supplemented by percolating waters.

The last is the hypothesis here advocated. Before entering argument in its support, we will, however, briefly present the objections to the acceptance of the others.

1. *Originally Deposited in a Concentrated Condition.*—This mode of formation is evidently out of the question with those deposits filling cavities or filling interstices of breccias formed subsequently to the rocks, in ways already described. It is, therefore, only applicable to such deposits as occur in beds, either in the diffused or disseminated form, or in massive sheets. In Missouri, only galena occurs in these forms. Now, though it may be theoretically possible for the chemical conditions to be such as to admit of the simultaneous deposition of galena and of such rocks as are found in the southeast, it does not seem possible under natural conditions. It would require a greater quantity of metalliferous minerals in the sea water than exist, or probably ever existed. Animals could not have lived in such solutions. If the ores were so derived, we should expect the deposits to be of wider and more generally uniform distribution than they are, especially where the lithologic characters are similar and the evidence of diffusion of organic matter is nearly equal. Finally, if other forms of deposits in the state, with some of which these disseminated or flat sheet bodies are closely associated, cannot be explained on this hypo-

thesis, the adoption of a different explanation of origin, merely because of difference of form, is not philosophical. The closest approximation to this theory is Whitney's explanation already referred to (p. 142). He, however, regarded subsequent segregation as necessary. Broadhead [31, p. 104] suggested that the galena in the state of solution had replaced "portions of the limestone beds which have previously been softened by acids." He says that the limestones were probably first formed; but whether the solutions referred to were oceanic, or traversing the rocks in crevices, is not stated.

2. *Derived from Great Depths, etc.*—This hypothesis claims consideration, because, with many ore deposits, it is doubtless a true one. Its strength lies in the probable preponderance of metals at great depths beneath the surface, and in the considerations that subterranean waters are of high temperature and under great pressure, and are consequently powerful solvents; that the relief of pressure and the diminution of temperature accompanying the ascent of such solutions would naturally cause the deposition of minerals. The obstacles to the acceptance of the hypothesis in the present case lie in local conditions. It was originally advanced for the upper Mississippi valley deposits by Owen and Percival [161 and 39, vol. iv, p. 367]. It has since been argued, with modifications, by others. The most recent advocacy has been in papers published within a year by Prof. F. Posepny [171] and Dr. W. P. Jenney [124]. The conclusions of these papers have already been discussed by the writer in an article in the *Journal of Geology* [246], from which we extract the following:

"The first of these papers, by Prof. Posepny, is a description and discussion of ore deposits in general, in which he advocates their deep-seated origin through the medium of hot solutions derived from great depths. The paper by Dr. Jenney is an exposition of his views concerning the origin of the Mississippi Valley ores, derived from his recent studies in the region. He repudiates the explanation of lateral concentration advocated by Whitney and Chamberlin, and reverts to the old ideas of Owen and Percival, that the ores have come from below—thus harmonizing with Posepny. * * *

Posepny's direct reference to the ores here discussed is brief. He marshals few facts from the region itself in support of his theory, but rather argues, in a negative way, that no great obstacles exist there which would prevent its acceptance. Thus, as positive evidence in Missouri, he states that while the deposits away from the granite and porphyry "islands" of southeastern Missouri consist chiefly of lead and zinc ores, "other metals, such as copper, cobalt and nickels occur as the Archean foundation rocks are approached." This circumstance, he concludes, is "an indication that the source of the lead deposits also is to be sought in depth." Whatever may be the value of this "indication," the facts, as

stated, do not hold generally. Professor Posepny reasons, presumably, from observations made at Mine La Motte, where such conditions exist. At other places, however, these changes in composition are not observed as the crystalline rocks are approached. At Bonne Terre, copper pyrite was found in the old upper workings, containing about four per cent of nickel and cobalt. It does not characterize the deeper ores. At Doe Run, a mine recently opened, work is prosecuted along the old water-worn, pre-Silurian surface of the Archean granites, amid the very conglomerate boulders, and very little copper pyrite with cobalt and nickel is found. Again, at localities in Ste. Genevieve, Franklin, Crawford and other counties, copper ores occur remote from any granite or porphyry outcrops, and well above the basal beds of the Silurian.

In the way of negative evidence, our author, in considering the Wisconsin deposits, seems to think the absence of ores in the great thickness of limestones and sandstones which underlie the productive horizons a by no means conclusive fact as opposed to their deep-seated source, and suggests that the solution may have come up through a passage not yet exposed, and even that fault fissures and eruptive dikes exist which have not been discovered. From the fact that he refers in this connection only to Whitney's report of 1862, we conclude that he has not had access to the later and more exhaustive works of Strong and Chamberlin. Perhaps, with the full light conveyed by these reports and accompanying maps, Prof. Posepny might have attached more importance to the objections raised. It is difficult to conceive how such a passage for the solutions, as he suggests, could possibly exist without its presence having been revealed and its course traced, with all the widespread mining and exploring which has been conducted in this region during the past 70 years. Neither can one see how the solutions of a crevice could traverse the intervening great thicknesses of water-soaked sandstone, without becoming diffused, in great part at least. The failure to find such a passage, and the absence of the ores in the beds assumed to have been traversed, though evidence of a negative character, is so strong that it becomes of almost positive value in support of the theory of lateral secretion.

Dr. Jenney, in support of his position, recognizes systems of fault fissures in the ore districts of both southwestern and southeastern Missouri, which cross each other in different directions; these, he considers, served as channels for the metal-bearing solutions, and the association of the fissures with the ore bodies he adduces as evidence of such derivation. The deposits of the southwestern portion of the state occur almost exclusively in the Mississippian or Lower Carboniferous limestone. Cross fissures or fault fissures in the rocks, if they exist, are not very apparent. The strata are undoubtedly very much shattered in certain limited areas, and have been subjected to extensive subterranean erosion and corrosion and great silicification. Of a system of extensive or considerable faults, recent stratigraphic work in this region has, however, revealed nothing.

In the Silurian limestones of the eastern part of the state the conditions are somewhat different. Crevices and fissures are there plainly developed, and evidence of considerable faulting is indubitable. In Franklin county, such vertical crevices have supplied large quantities of ore. In that portion of the southeast to which reference is especially made, however, and which has produced by far the bulk of the lead, the crevices, whether marking faults or not, are of insignifi-

cant dimensions, and the experience has been that they contain, themselves, little or no ore. On the contrary, the great ore masses consist of galena disseminated through a thickness of the country rock, often of fifty feet or more. At Bonne Terre a tract of 1300 feet long by 800 wide has been mined out of such diffused ore. The crevices which traverse this ore body are frequently almost blind, and can only be detected by the drip of roof water. These are such as occur in almost any massive rock. Further, one of the most important faults in this region, which traverses the country about two miles north of Mine La Motte, with an apparent throw of 300 feet, is entirely unaccompanied by ore, though the adjacent ground has been prospected with the diamond drill. Again, not a single instance can be recalled by the writer, in those mines which work to the very contact with the underlying granite, where faulting or other crevices extend down into that rock. They possibly do so extend in some instances, but there is no positive evidence adducible that they then continue ore-bearing. Apart from this, however, the association of ore and crevices, of course, does not connote by any means a deep-seated source for the ore. Such crevices generally act both as channels controlling their distribution, and as receptacles for their accumulation, whatever the source of the ores. Hence, a disturbed and creviced region, which is in other respects adapted to the reception of ores, will be their most natural habitat. Therefore, the explanation of the localization of the deposits based upon such conditions is equally consistent with any of the common theories of ore derivation.

The same, it would seem, can be said concerning the observed paragenesis of the minerals and the growth of crystals, in which Dr. Jenney sees additional foundation for his conclusions. If we accept the broader idea of lateral secretion, which does not demand that a mineral shall be derived from the very rock to which it is attached, but recognizes abundant flow along crevices and through porous strata, and a consequent free transfer of solutions from place to place, all the phenomena find at least an equally ready explanation.

It is argued further, in this paper, as against the lateral secretion theory, that the metallic contents of the country rocks are insufficient to have supplied the ore bodies. The grounds for this statement are only suggested; but, to the best of our knowledge, the fact yet remains to be proven. Due allowance is not made for the many and various ways in which minute quantities of substance, disseminated through vast volumes of rock may be brought together.

In evidence of the post-Carboniferous age of the deposits, the statement occurs several times in Dr. Jenney's paper, that the ores occur in the Coal Measures. This, we think, should be made with limitations. They are found in shales of that age in Jasper county, and a few other localities, but these shales are in isolated patches, which occupy depressions in the older, ore-bearing Mississippian rocks. The metallic contents of the coal may, hence, be derived, by some secondary process of transfer, from adjacent ore bodies. In any case, the Coal Measures in the state, as a whole, are practically destitute of these ores, and they can thus hardly be stated to occur in that formation, whether their absence be due to their prior formation, or to limitations in their distribution determined by physical causes.

Dr. Jenney seeks further to find support for the hypothesis of the deep-seated origin of the ores through analogy, in stratigraphy and geologic history, with

regions of the far West. This attempt does not seem, in our judgment, to be successful. The last pronounced regional disturbance of both the Ouachita* and Ozark uplifts was immediately after the Coal Measure period. In Arkansas, this was accompanied by great flexing of the strata. There is no evidence in the Ozark uplift of any intense disturbance of post-Cretaceous date, or of the presence, even at great depths, of flows of such igneous rocks as accompanied the uplift and preceded the ore formation of the Rocky mountains. As already expressed, the Missouri ores cannot be properly considered to occur in the Coal Measures of the state. Did such a profound fissuring take place in post-Cretaceous times as Dr. Jenney's hypothesis requires, we should expect to find it extending into the body of the Coal Measures, accompanied by the ores. At least faulting or other such exhibition of disturbance would be found, which phenomena do not characterize these rocks.

Over and above these considerations affecting the quality of the support of this theory, there still remain the positive obstacles to be disposed of. The almost entire absence of the precious metals in the Missouri ores is a fact which further weakens the force of any analogy which may exist between their conditions of deposition and those of the Rocky Mountain ores. How are the objections raised by Whitney and Chamberlin, discussed in a previous paragraph, to be met—such as the facts that faults are practically absent from the region; that there is little ore in the underlying Lower Magnesian beds and none in the Potsdam and St. Peter's sandstones; that no deep and continuous crevices like true fissures are found; that no hydrostatic cause is assigned for the ascension of the solutions from great depths. How could the ores be carried across such thick, pervious and water-soaked strata as those of the Potsdam and St. Peter's formations?

The generally accepted facts that the deeper-seated rocks are richer in metallic constituents; that subterranean waters are of high temperature and under great pressure, and consequently are powerful solvents; that the relief of pressure and the diminution of temperature accompanying the ascent of such solutions supply an abundant cause for the deposition of their metallic burdens, are all good and enticing general reasons in favor of the adoption of the theory of a deep source for *all* of our metalliferous deposits. Yet, on the other hand, we must recognize that *some* of our ores, notably those of iron and manganese, cannot be assigned such an origin. Why is it not possible, on general grounds, that other ores should be gathered as are those of these two metals? In reply, it is manifest that we cannot rely entirely upon such general principles, as they are at present understood; but must still resort to specific facts in connection with special cases. Few definite facts relating to this Mississippian area have been adduced in these recent papers which can stand as new reasons for believing in the deep origin of the ores, an explanation long since offered by Owen and Percival. Neither have we attempted to introduce positive demonstration in opposition to it. The question seems to be very much *in statu quo*, and, so long as it so remains, the old objections hold good and must be done away with before a change of opinion is warrantable."

* Post-Cretaceous eruptions took place in central and southern Arkansas; but, as stated by the writer in 1890 [247-p 231], they were not accompanied by great crustal movements. According to Branner, not even the Cretaceous and Paleozoic rocks in the immediate vicinity are much disturbed or altered.

In addition to the reasons given above, we might further add that many, if not all, of the crevices, contract and diminish in ore contents with depth, and are often essentially surface phenomena. Whitney long ago called attention to this fact, as referred to on page 139. The Wisconsin ores, which are found at different horizons, from the Lower Magnesian to the Galena limestones, do not simply extend through the upper strata down to the lower, but characterize only the exposed portions of these formations, and this only to certain limited depths.

3. *Original Diffusion Supplemented by Lateral Sections.*—The application of this theory to the explanation of ore deposits in general has been quite prevalent during the past twenty years. It was stimulated principally through Sandberger's [199] investigations and publications upon the presence of metals in rock-forming minerals. In this country, Emmons' monograph on the Leadville deposits has done more than any one other work to bring the theory into prominence. During recent years, however, strong opponents have appeared, and something of a reactionary movement has maintained. Objections and obstacles have been raised, and in some cases, doubtless, the inapplicability of the theory has been shown [171, pp. 249, 250]. The sufficiency of the metalliferous contents of the country rocks has been questioned [171, p. 203]. Prof. A. Stelsner [213] investigated Sandberger's methods of analysis, and concluded that he had not determined decisively whether the metals in the minerals were original constituents, or secondary impregnations derived from the ore deposits. This is, of course, a very difficult thing to prove positively; yet the presence of these metals diffused through rocks, at localities remote from deposits, as will be instanced later, is strong presumptive evidence that they are original constituents.

In a recent paper on the origin of lead and zinc deposits in soluble rocks [172], which has come to the writer through the kindness of Prof. Posepny, the latter lays stress upon certain objections to the lateral secretion theory, which seem to him insuperable. Briefly stated, these are: 1) that sulphides are not formed in the presence of air, and therefore, cannot have been formed in the surface or "*vadose*" regions, and must have been formed at depths (pp. 6, 54); 2) that lateral secretion is only conceivable in the *vadose* regions, where the solutions can flow into cavities, and there, only oxidized compounds would be deposited (p. 54); 3) that in none of the "thousands of analyses" of limestones remote from ore deposits has the presence of foreign metals

been shown (p. 44); 4) that it does not seem possible that the whole array of minerals which are found in ore deposits in such rocks, including Pb, Zn, Ag, Au, Cd, Fe, Mn, Co, Ni, etc., could have come from a different source and direction than the metals of other ore deposits (p. 53).

Regarding the first objection, we can readily conceive air to be excluded from the interstices, and even cavities of rocks near the surface, and for oxidation to be *nil*. Though it is probably true that oxidation is exclusively a *vadose* phenomenon, the reverse does not follow, nor does experience teach us that it does. Posepny himself cites (p. 54) the formation of sulphides through the influence of organic matter, and where the latter is abundant at the surface, and in the proper condition, deoxidation and the deposition of sulphides may prevail.

As to the second objection, deposits formed by lateral secretion are not necessarily cavity fillings; segregation and replacement of rock by the metalliferous solutions is, at least, as possible here as by other processes.

Prof. Posepny's statement concerning the absence of foreign metals in limestones is difficult to reconcile with the results quoted in chapter III of this report. Just what analyses he refers to, we do not know; of course many thousands have been made of limestones, in which no thought was given to the detection of these metals, and which, moreover, were not sufficiently refined for the presence of very minute quantities to be revealed. Mr. Robertson's results, quoted later, suggest that this may be the explanation. The statement certainly does not apply to the limestones of the Mississippi valley.

Concerning the final objection, the mere presence of a long array of metals in deposits of the class under discussion, seems to the writer to have little or nothing to do with the questions of their immediate origin and mode of accumulation. Their relative quantities has, perhaps, more direct bearing. On any theory deserving recognition, all the metals of our ore deposits are constituents of the earth's crust. It is natural to infer that they would all be diffused through its rocks, as well as segregated in deposits; the amounts so diffused would be somewhat proportioned to the solubilities of their more common compounds.

Some opponents and some advocates of the theory of lateral secretion have, apparently, a somewhat narrow conception. They

would restrict the source of the ores to the rocks immediately contiguous to the ore body; they would allow of only *lateral* flow of solutions. A somewhat broader conception of the theory permits the minerals to have been derived from any or all of the country rocks, and recognizes that solutions may traverse these rocks in all directions, according to local conditions. Thus, the solutions may in some cases rise, and, in one sense, come from below; in another case they may descend, and thus come from above; again, they may flow into a cavity from the sides. The distribution of the minerals in any body, whether attached to the roof, sides or bottom of a cavity, is, hence, immaterial. The theory may be thus considered to grade at times into that of the derivation by solutions from depths. The main point of difference is that the flow of the solutions is generally controlled by ordinary hydrostatic conditions, rather than by volcanic agents.

Some opponents of the theory decry it, upon the grounds that it is a convenient one and can be argued from the laboratory and office, without the trouble of field and mine studies. We see no justification for this accusation. Knowledge of the actual conditions is as necessary in the one case as in the other.

To explain the Upper Mississippi valley ores, lateral secretion has been used to some extent by Whitney, but principally by Chamberlin; even with the latter, however, it was secondary, the original concentration being attributed to oceanic currents, in the manner already outlined on p. 143. That it is an agent in the formation of these deposits we also recognize. But that it is *per se* sufficient to supply the great bodies of ore of many Missouri deposits we do not believe, even though such local concentrations exist as Chamberlin's hypothesis would provide for. The country rocks surrounding the large ore bodies do not present the leached appearance which would seem necessary.

A modification of this theory has been proposed by F. L. Clerc [242]. He advocates that the ores were derived from patches of Coal Measure shales, which are so abundant in southwestern Missouri. As instrumental in affecting this result he requires a Quaternary submergence, during which the ores diffused through these shales were leached out and deposited in the underlying breccia. An objection to this proposition is that such Coal Measure pockets are by no means always associated with the deposits. Further, they are not readily traversed by waters, being, on the contrary, dense and impervious. Finally, if

derived from these rocks, we should expect to find bodies of ore in the interior of the Coal Measures.

Mr. Carl Henrich, in a recent description of the Webb City deposits [253], refers to the bitumen of the limestones as instrumental in the reduction and deposition of the sulphides.

Mr. Nason, from his observations in Missouri, is opposed to the idea that the lead and zinc ores were derived from depths [154, p. 636]. He states that there is no evidence of deep-seated thermal springs, and that all the evidence is in favor of a downward circulation of the waters, and of a transmission of metalliferous compounds from above to the lower levels.

4. *Concentration through Surface Decomposition.*—This hypothesis, which we now formally advance, starts with the proposition that the metalliferous minerals originally existed in the Archean rocks, either in a disseminated condition or in veins. With the decay of these early rocks, the minerals became diffused through later formed sediments, this diffusion being quite uniform over contiguous areas. Successive decaying of successively formed rocks simply resulted in a transfer of these minerals.

This hypothesis so far agrees with Chamberlin's, in that it recognizes the presence of minerals in the country rocks and the derivation of the deposits from them. It differs, however, in maintaining a condition of general diffusion, rather than one of concentration, over certain favored areas. Chamberlin's hypothesis of oceanic currents has always seemed to the writer inadequate, and too theoretical. It does not meet the fact of the differences in the ages of the rocks in which the deposits are found. His diagram exhibits the currents of Silurian times, while the deposits of southwest Missouri are in Lower Carboniferous rocks.

According to our theory, the concentration is entirely secondary. It is, primarily, a result of great and long-continued surface decay of the rocks; and, secondarily, the result of the presence of local favorable physical and chemical conditions. Important examples of such, we will enumerate later.

Recent studies of Mr. W. P. Blake in the Wisconsin area have led him to express views in a recent paper [21, p. 621] which seem to the writer to be leading to similar conclusions. He recognizes the presence of faults there, but does not seem to see that they indicate a deep source for the ores. On the contrary, he regards the evidence,

all things considered, as favoring lateral secretion, combined with a *descent* by solution. He favors an original general dissemination of the ores in the masses of the strata, and "from which during decomposition they are drawn or leached, and finally concentrated in the fissures or crevices." The method of doing this he expresses in the following words :

"The evidence is strongly in favor of the view of the long-continued decomposition, downward flow and re-composition of not only the ores of zinc, but of lead and of the pyrite, from the upper formations to the lower, as the general water-level of the region subsided, and as the upper formations, by long-continued exposure through geologic ages, were gradually decomposed in place. By such a process the present zinc deposits would seem to have accumulated, and to represent the originally diffused ores in many formations, possibly as high in the geologic scale as those of Missouri, or the Lower Carboniferous. This is, however, improbable, owing to the dense and impervious nature of the intervening Hudson river shales."

Faulting, Mr. Blake considers an indirect cause in localizing the ores. The original deposition of the sulphides from the sea, he attributes to the decomposition of organic matter. He suggests that an incursion of hydro-carbons, perhaps caused by dislocations, may have also produced this result. The presence of the bituminous shale known as "oil rock" at the base of the Trenton he emphasizes as significant in this connection. The ore bodies often terminate with this, and spread out along its upper surface. If it did not determine the original deposition of the ore, he concludes that it certainly had a strong secondary influence.

With reference to the surface decay of the rocks, he makes the following statement of special interest in this connection :

"It is a significant fact that the lead-producing region has not been glaciated, while the glaciers extended over the adjoining regions. This evidence is in favor of the view that the deposits have been formed by leaching downward, the unglaciated area having been long exposed to atmospheric agencies and decomposition, without removal, while the rocks were decomposed *in situ*. Similar conditions prevailed in Missouri, where, according to Dr. Jenney, the land has been above water from the beginning of the Carboniferous period to the present time."

To place the hypothesis on a firm foundation, it is necessary, first, to present evidence of the truth of the fundamental proposition, that the metals are diffused through the country rocks. In chapter II of this report, we have made certain statements and have quoted certain results indicating the general diffusion of minute quantities of lead and zinc in minerals, rocks and ground waters. To bring the evidence

nearer home, a series of examinations of Missouri rocks were undertaken. These were conducted by Mr. Robertson with great care, and after much preliminary experimentation;* duplicate and sometimes triplicate analyses were made, in order to confirm the results. Working with such bulky samples as had to be used, a great amount of time and labor were necessary. The samples were mostly collected by the writer in person, and the analytical work was done in the Survey laboratory. Part of these were collected at considerable distances from known bodies of ore, and some are from points outside of the mining districts entirely. The results of this investigation are given in the following tables:

METALLIFEROUS CONTENTS OF ARCHEAN ROCKS.

J. D. Robertson, Analyst.

	Lead.	Zinc	Copper.	Manganese	Survey Nos.	
					Anal.	Catal.
1. Granite, Graniteville, St. Francois Co	<i>Per cent</i> 0.00272 0.00204	<i>Per cent</i> 0.00240 0.00300	<i>Per cent.</i> 0.01040 0.01000	<i>Per cent</i> 0.04890 0.04960	469a 469b	1259
2. Granite, Clearwater, Reynolds Co	0.00204 0.00197	0.00189 0.00160	0.00240 0.00290	0.00574 0.00612	477a 477b	4037
3 Porphyry, Hogan, Iron Co	0.00496 0.00509	0.01760 0.01650	0.00400 0.00300	0.01000 0.00901	472a 472b	1253
4 Diabase, Skrainka, Madison Co	0.00680 0.00612	0.01600 0.01360	0.00720 0.00720	0.01750 0.01820	471a 471b	1261

Notes.—No. 1 was taken at Graniteville. It is a red granite, composed of pink orthoclase in large quantity, transparent quartz in imperfect crystals in less quantity, and biotite in small crystals in very small quantity. An analysis of the soluble portions of this rock, made by leaching 1000 grams (the rock being crushed to $\frac{1}{32}$ inch and less) with nitro-hydrochloric acid, and careful washing with ammonium tartrate, yielded:

Lead, 0.00136%; zinc, 0.00216%; copper, 0.00176%; manganese, 0.00197%.

The residue, when examined under the microscope, showed a mass composed almost wholly of quartz and feldspar, with very few crystals of biotite.

No. 2 was taken a few miles north of Clearwater. It is similar to No. 1, but contains less mica. An analysis of the soluble constituents, made in the same manner on 100 grams of rock, gave:

Lead, 0.00095%; zinc, 0.00075%; copper, 0.00080%; manganese, 0.00013%.

No. 3 was collected about one mile east of Hogan. It is a dark greenish rock, containing white crystals of plagioclase in a felsitic ground mass. An analysis made by leaching 100 grams, as described, gave:

Lead, 0.00061%; zinc, 0.00023%; copper, 0.00056%; manganese, 0.00766%.

* A description of the methods of analysis pursued is given in Appendix B of this report.

An examination of the residue after leaching, showed many fragments of the ground mass apparently but slightly acted upon.

No 4 was obtained at the quarry at Skrainka. It is a dark green, tough rock, containing considerable plagioclase (probably oligoclase with some albite) and angite in nearly equal quantities. On leaching 133 grams, the following results were obtained:

Lead, 0.00500%; zinc, 0.00504%; copper, 0.00391%; manganese, 0.00036%.

The residue was composed of fragments of more or less decomposed angite and plagioclase, the decomposition being apparently less perfect than with any of the preceding specimens.

All of these rocks showed the presence of barite, and in No. 3 a considerable quantity was found, many times as much as was determined in any of the limestones. The inference is that the other crystalline rocks contain large quantities likewise; difficulties encountered in the analysis prevented a determination of the amounts in these other specimens.

METALLIFEROUS CONTENTS OF SILURIAN MAGNESIAN LIMESTONES.

J. D. Robertson, Analyst.

	Lead.	Zinc	Copper.	Manganese	Barium sulphate.	Survey Nos.	
						Anal.	Cstl.
5. Jefferson county— Frumet mines.....	<i>Per cent.</i> 0 00041 0.00061	<i>Per cent.</i> 0 01528 0 01536	<i>Per cent.</i> 0 06208 0.00200	<i>Per cent.</i> 0 00035 0 00030	<i>Per cent.</i>	506a 506b	
6. Miller county— Rothwell diggings	0.00156 0.00143	0 00080 0.00024	0 00040 0.00064	Trace. 0 00049	..... .....	505a 505b	
7. Pettis county— Near Smithton.....	Trace ..	0.00040 0 00040	0 00048 0 00108	Trace. ..	0 0017 0 0020	489a 489b	
8. St. Francois county— Desloge mine.....	0 00129 0 00129	0 00528 0 00503	0 00240 0.00256	0 03122 0 03372	0 0040 0 0050	476a 476b	3678
9. St. Francois county— Railway tunnel Valle mines	0.00102 0 00132	0 00408 0 00400	0 00056 0 00192	0 00306 0.00290	0.0011 0 0010	475a 475b	3684
10. Wright county— Mansfield.	0 00133 0.00130	0 00016 Trace	0.00056 0.00048	Trace ..	..... .....	484a 484b	2870

Notes.—No. 5 was taken from a shaft at Frumet where no ore had been found. It is a light buff, cellular, dolomitic limestone, slightly siliceous, and contained very little organic matter.

No. 6 was obtained from a prospect shaft near the old Rothwell diggings. It is drab in color, compact, contains a few fragments of transparent quartz, and some clay.

No. 7 was taken from an outcrop near Flat creek, about 4 miles southeast of Smithton. It is a buff, earthy, compact, dolomitic limestone, with considerable clayey residue and little or no quartz or chert, and practically no organic matter.

No. 8 was collected from the dump of the deep shaft at the Desloge mine. Close examination failed to disclose any metalliferous minerals. It is a dark gray, compact, slightly siliceous, dolomitic limestone. It contains much clayey matter, but no chert and very little organic matter.

No. 9 was obtained from the tunnel on the M. R. & B. T. R'y. It is a hard, cellular, somewhat siliceous, dolomitic limestone, containing very little clayey matter and but little organic matter. It contains some white chert and a small quantity of pyrite in a finely divided state.

No. 10 was taken from an outcrop about half a mile south of Mansfield, and several miles from any known deposit of ore. It is soft, compact, earthy, dolomite, with a large amount of clay, but no chert or quartz or organic matter.

In none of these or other samples of rocks analyzed were there visible quantities of metalliferous minerals.

METALLIFEROUS CONTENTS OF LOWER CARBONIFEROUS LIMESTONES.

J. D. Robertson, Analyst.

	Lead.	Zinc.	Copper	Manganese	Barium sulphate.	Survey Nos.	
						Anal.	Catal.
11. Greene county— Phenix quarry.....	Per cent 0 00061 Trace.	Per cent. Trace Trace	Per cent. 0 00048 Trace	Per cent. Trace. Trace.	Per cent.	481a 481b	3670
12. Jasper county— Carthage quarry.....	0 00068 0 00048	0 00152 0 00160	0 00048 0 00048	0 00700 0 00756	0 00022 0 00020	478a 478b	
13. Jasper county, Joplin— Bluff on Turkey creek....	0 00084 0 00088 0 00027	0 00128 0 00120 0 00134	0 00096 0 00048	0 00084 0 00084	0 00047 0 00049	482a 482b W. B. P.	
14. Jasper county, Webb City— Near Sucker flats	0 00260 0 00272	0 00088 0 00120	0 00128 0 00120	0 00120 0 00126	0 00037 0 00019	483a 483b	
15. Lawrence county— Half mile south of Aurora.	0 00346 0 00333	0 00072 0 00080	0 00080 0 00065	Trace Trace.	0 00012 0 00007	478a 478b	
16. Pettis county— Sedalla quarry.	Trace. Trace.	Trace. Trace.	0 00012 0 00040	0 00091 0 00035	Trace. Trace.	488a 488b	
17. Pike county— Louisiana quarry	0 00068 0 00068	0 00248 0 00255	0 00256 0 00240	0 00209 0 00200	..... .....	474a 474b

Notes.—No. 11 was taken from the quarry at Phenix, remote from any ore deposits. It is a white, coarsely crystalline limestone, quite pure, and carries but little organic matter.

No. 12 was collected at the quarry of the Carthage Marble company, just north of Spring river. It is a nearly white, coarsely crystalline limestone, very pure, save that it contains a noticeable quantity of organic matter, which separates out, on solution in hydrochloric acid, as a black, slimy mass.

No. 13 was taken from a bluff north of Joplin, near the point where the Girard branch of the St. L. & S. F. Ry. crosses Turkey creek. It is a white, coarsely crystalline limestone, containing a large quantity of organic matter. A different sample, collected by Mr. Robertson in 1890, from the same locality, was analyzed by Prof. W. B. Potter, of St. Louis, and the results, marked W. B. P., are given in the table.

No. 14 was collected from an abandoned shaft south of Webb City, where no ore had been encountered, and where no shafts had struck ore for a considerable distance in every direction. It is a white, crystalline limestone, quite pure, save that it contains a very large amount of organic matter.

No. 15 was taken about half a mile south of Aurora. It is a grayish white, coarsely crystalline limestone, containing considerable organic matter, but otherwise quite pure.

No. 16 was taken from a quarry just north of Sedalia. It is light drab in color, contains a small amount of chert and but little organic matter.

No. 17 was taken from the Crystal Carbonate Lime company's quarry at Louisiana. It is a very pure, white, coarsely crystalline limestone, with little or no organic matter.

A study of these results shows that the essential elements of the ore bodies in question are present in these rocks. The amounts of metallic lead vary from about 0.0004 to 0.007%, of metallic zinc from about 0.0002 to 0.018%, and of copper, manganese and barite there are correspondingly small amounts. The largest percentages of the metals appear to be in the crystalline rocks. The number of analyses is not sufficient to establish this definitely, but, if true, this relation is in harmony with the idea of the derivation of the metalliferous contents of the limestones from the pre-existing crystalline rocks. Were the metalliferous contents due to secondary impregnation from fissures, we should expect to find a smaller proportion in the comparatively impermeable crystalline rocks than in the soluble and comparatively porous limestones. The presence of both zinc and lead in limestone from Louisiana, which is north of the Missouri river and remote from the mining districts, supports the belief that these metals are generally diffused. Moreover, the contents is greater than that of some of the limestones from the very centers of lead and zinc mining.

Averaging the contents of the limestone, we obtain the following results:

0.001009% metallic lead=0.00117% galena (Pb S).

0.00239% metallic zinc=0.00359% blende (Zn S).

This is equivalent to:

0.00198 lbs. of galena to 1 cubic foot of rock.

0.00603 " blende " "

From this, the contents of different areas are as follows:

87.0 pounds galena per acre 1 ft. thick.

27.8 tons " per square mile 1 ft. thick.

13,900 0 tons " " " " 500 ft. thick.

261.0 pounds blende per acre 1 ft. thick.

83.6 tons " per square mile 1 ft. thick.

41,500.0 tons " " " " 500 ft. thick.

From these figures, we see that the metalliferous contents of 500 ft. of limestones covering about 3 square miles is equal to our annual production of lead and zinc ores; while the contents of about 70

square miles equals our total production of lead ore, and the contents of about 30 square miles, our total production of zinc ore.

It thus appears, on this hypothesis, which does not require that the ores should come from the *immediately* adjacent wall rocks, that the metalliferous contents of the country rocks are ample to supply the ore deposits.

The fact that the blende and galena in the rocks are proportional to the present annual productions of these ores, must be regarded as a coincidence. Were the relation maintained in the case of the total productions, and were lead and zinc ores both equally abundant in all of the mining districts, it would be a strong confirmation of the hypothesis.

The combinations in which the metals and other minerals exist in the rocks could not be determined with the means at hand. It is probable that these are carbonates, sulphates, sulphides and silicates. Whether one or all of these, it may be assumed that, with the general decay of the country rock, these minerals would be affected also, and would pass into solution, at least in part. A portion of such solutions would flow off in surface waters and streams, and would be transported long distances, to be emptied into some lake or lagoon, or to pass into the ocean. Portions would percolate downward and enter the rocks. Where crevices existed, or where depressions were formed, the waters would converge and the flow would be more abundant. Where physical and chemical conditions were favorable, deposition of minerals would take place, the amounts being proportional to the strength and volume of the solutions. Favorable physical conditions are open cavities, interfragmental spaces of breccias, pores in massive rocks, etc. Favorable chemical conditions are, principally, the presence of reducing agents, such as organic matter, which was doubtless the main agent in the precipitation of the ores.

These facts determined, and conceding that the above outlined processes are not only possible, but reasonable, what evidence do we find in the geologic history and conditions of the deposits, that such has been their mode of formation?

In answer to this question, we adduce the fact emphasized in the chapter on geologic history, that this region has been one of great and long-continued sub-aerial decay during different geological periods. From the beginning to the present time, many hundreds of feet of rock must have been removed.

That the Wisconsin area has had a similar history, is confirmation of the belief that this cause has been influential. The great length of the erosion period is referred to by Blake, and was noticed by Whitney, Strong and Chamberlin, but its full bearing upon the ore deposits does not seem to have been appreciated. The derivation of the deposits from the whole mass of the country rock, and not simply from those immediately adjoining the deposits, answers an objection raised by Dr. Jenney to the theory of lateral secretion; and the source of the magnesia of the dolomites of the southwestern Missouri ore breccias is thus readily explained. Further, the theory accounts for the essentially superficial nature of most of the ore bodies. This condition exists in Wisconsin, and is described by Whitney (see p. 139), Chamberlin and Blake. It is also undoubtedly a characteristic of the Missouri deposits, though the disseminated ores of the southeast seem exceptions. Through the derivation of the minerals from above, we can explain the filling of those crevices and other cavities found in Missouri which diminish in size and ultimately terminate downward. Finally, this theory offers an explanation for the association of bulky deposits, like those of lead and zinc, with the comparatively soluble limestones, a fact observed and commented upon by all students of ore deposits; the decay of these rocks in such large volumes furnishes correspondingly large deposits.

These are the general conditions which are in harmony with the hypothesis; next to be considered are the local and special conditions. Do they yield additional support? Or, putting the question in another way, are they readily explicable in this way? We think so, in great part at least. The occurrences being local and special, however, are attributable to special conditions prevailing at certain times and places.

Taking, first, the southwestern Missouri district, we have there great bodies of breccia impregnated with ore. These breccias fill large spaces or "caverns" in the country rock, which have resulted from surface decay. The breccias are composed of residuary materials, associated with metalliferous and other minerals. They are in Lower Carboniferous limestones, and must, hence, have been formed later. We have already emphasized the fact that, immediately after this epoch, before or during the early Coal Measures, was a time of vigorous erosion. This, doubtless, affected not only the marginal Lower Carboniferous rocks, but the Silurian magnesian limestones of the interior also. With the emergence after the deposition of the Lower

Carboniferous limestones, the rain-fall was probably great and drainage abundant. The geologic map shows a tongue of Lower Carboniferous rocks extending from southwestern Missouri eastward into the Ozark area. This, probably, marks the site of a former estuary toward which drainage converged. Thus, a great volume of water was probably discharged into this basin, bringing the products of decomposition of the magnesian limestones and of other rocks to the east. To this source we attribute the magnesia which dolomized the Carboniferous limestone in the earlier stages of the erosion of the Jasper county area. After this, as the Coal Measure epoch developed, vegetation became dense, swamps were formed, vegetable matter began to decompose and coal beds to accumulate.

Here, then, were furnished almost perfect conditions for the reduction of the ores in solution. Already, great quantities of residuary materials had accumulated, from the decay of the Lower Carboniferous rocks *in situ*. In addition, the drainage was constantly supplying new solutions and matter in suspension from a distance. Upon all of these, the organic matter acted.* Ideal physical conditions were furnished by sink-holes, caverns, etc., filled with breccia, as have been described. Under these circumstances, the deposition of the ore must have been rapid and abundant. The silicification which gave rise to the secondary cherts of these bodies must have taken place at the same time or shortly after. To the post-Lower Carboniferous or early Coal Measure epoch, we therefore assign the formation of the principal deposits of southwestern Missouri. Others were doubtless formed at other times, and additions may have been made to these later, but that was the time of greatest activity. These were the special conditions of time and place which supplemented the general condition of surface decay in producing the deposits of the Southwestern district.

An inference of importance to the mining interests, to be drawn from the above history, is that at least the large brecciated deposits must be confined to the depths of decomposition of the rocks by surface waters. Also, we cannot expect to find such ore bodies in those Lower Carboniferous rocks that have not been subjected to surface

* As bearing upon the chemistry of the process, we quote the following from Bischof:

"Water saturated with carbonic acid dissolves 1-4103 of its weight of artificial carbonate of zinc. Sulphuret of potassium precipitates from this solution white sulphuret of zinc. If, therefore, water contains alkaline or earthy sulphate, organic matter and carbonate of zinc, the conditions for the formation of zinc blende are complete." [15, vol i, p. 15].

decay.⁷⁷ So far beneath the Coal Measures as we can trace the past erosion of these rocks, so far may we look for the ore. Beyond this, they will not be found.

The origin of those deposits of the Southwestern, and also of the Central and Southeastern districts, which occur in vertical crevices or in cavities of other shapes and attitudes, we ascribe to the convergent flow of waters which have leached surface residues and have passed through decomposing rocks. The cavities furnished the requisite physical conditions; the chemical condition necessary was the presence of organic matter. This probably existed in all epochs, but was most abundant during the Coal Measures, and this was doubtless the time of maximum enrichment of these deposits also. The finding of galena and blende within the very coal beds of outlying marginal coal pockets shows the influence of carbon in their deposition.*

The distribution and character of the disseminated ores of the southeast are more difficult to explain. Though they are often mined at considerable depths, they are also found near the surface. One of the principal determining causes, we think, was the original open structure or texture of part of the rock. This is often observable now, and specially characterizes ore-bearing strata. Second, a prevalence of organic matter in certain strata or along certain horizons, as indicated by a darker color now often seen, had doubtless influence. Further, the various shale beds probably limited and guided the solutions, as referred to in describing the Bonne Terre deposits.

The numerous vertical crevices furnished channels for the flow of the solutions. The sheets of galena frequently found in these crevices prove that the solutions followed them. These were sufficient to supply the ore of higher-lying disseminated bodies. The contraction and disappearance of the crevices with depths, make them inadequate for the deep deposit such as prevail along Flat river. For these ores we are inclined to refer to the underlying sandstone, which is in close proximity, as the solution carrier. This is saturated with water, much of which flows directly from decomposing crystalline rocks. The sandstone itself contains particles and fragments of these rocks,

* The question may suggest itself here, why, if the Coal Measure epoch was so favorable for the deposition of ores, are such not abundant within the coal area proper? Our answer to this is, that the conditions of the interior of the Ozark uplift or along the margin were so conducive to the deposition of the ores, that little remained to be carried far from the shore line. Instances of the occurrence of both lead and zinc compounds in small quantities are, however, common in the Coal Measures; those of Miami and Linn counties, in Kansas, are the most noteworthy.

which must hold more or less of the metals. A downward flow of water toward Flat river and Bonne Terre is induced by reason of the slope of the Archean floor, and also probably by the Farmington anticline to the east which we have described. The water is, thus, under pressure sufficient for it to rise up through the limestones, and where suitable physical and chemical conditions are reached the deposition of the ore will take place. We are inclined to think that the formation of the ore is still in progress; the finding of galena on calcite crystals, already referred to (p. 453), is evidence of this. In the southeast, as elsewhere, however, the Coal Measure epoch furnished probably the most favorable conditions. Decomposing organic matter was doubtless introduced into the rocks through solutions. The proximity of the Illinois coal field had probably also a localizing influence.

We have thus given in some fullness a statement of the causes and processes involved in the formation of these deposits. We think the conclusions rest upon a good foundation of facts. Still, there is much which it is difficult, if not impossible, to explain with our present knowledge. Much must be left for future investigation; but we feel that this report will be serviceable in directing such. The causes controlling the localization of the deposits should be inquired into. Additional analyses should be made, which will permit generalization as to the distribution and relative quantities of the metals in the different rocks, and as to the combinations and conditions in which they exist; careful examinations of residuary clays will furnish valuable data. Observations should be made to detect whether ores are at present in process of formation, especially galena and blende. If so, why do we find the observed paragenesis of the minerals? The chemistry of the processes of solution and deposition of the ores needs further investigation. These are some of the problems to be attacked; others will suggest themselves to the careful reader and observer.

CHAPTER XIII.

INDUSTRY AND STATISTICS OF LEAD AND ZINC IN MISSOURI.

SMELTING AND MANUFACTURING.—STATISTICS OF MINING.

The mining of lead and zinc ores and the manufacture of the metals constitute a great industry in the state. A large amount of capital is invested, and large fortunes have been made. The history and development of the mining industry, and, incidentally, of the smelting industry, have been described in previous pages, and but brief reference will, therefore, be made in this chapter to past events. Full descriptions of the mines are given in part III. Therefore, in the present chapter the purpose will be to give a succinct description of the smelting and manufacturing industries at the present time, to which will be added a series of statistical tables of the production of ores and metals to date.

SMELTING AND MANUFACTURING.

By J. D. Robertson.

LEAD SMELTING.

Lead was the first metal smelted in Missouri, possibly on account of the ease of the operation. The log furnace is the earliest form of furnace described, and this was used probably as early as 1720. After 1798, its use began to decrease, owing to the introduction of the ash furnace by Moses Austin about that time; but, in some localities, it was still to be seen at a much later date. Thus, it was in use at Cadet, in Washington county, as late as 1864.

It is very probable that the references to the reverberatory furnace in southeastern Missouri in early times apply to the ash furnace, which was formerly used in connection with the log furnace, but gradually died out.

The Scotch hearth, perhaps in use before 1819, but certainly introduced about 1836, in Washington county, did not come into general use until a somewhat later time. Such are still in operation at several localities, but many have been replaced by air furnaces.

The earliest reference to the air or Drummond furnace is in Swallow's report of 1855, which states that Geo. W. Mosely erected one in Newton county in about 1850. After this, they gradually spread to central and southeastern Missouri. In 1873-1876 there were quite a number in operation, particularly in central Missouri, but of late years most of these have been abandoned.

The Flintshire furnace has never been extensively used in this state. Two furnaces of this type were built in Granby about 1874, and were run for several years. One was built at the Frumet mine about 1870, and about 1875 two or three were erected at the Desloge works at Bonne Terre. The Frumet furnace was run for some years, and was considered quite successful. Those at the Desloge works were finally abandoned in 1883, after some experimenting in connection with the cupola furnace. The Desloge Consolidated company of Desloge have erected two Flintshires within the last few years.

The first cupola or stack furnace was erected at Mine La Motte in 1870, and one was built by the St. Joseph Lead company at Bonne Terre in 1874. The Desloge company erected theirs in 1880, and the Doe Run company theirs in 1887. The Desloge works were destroyed by fire in 1886, and the property was purchased by the St. Joseph Lead company. The furnace was not rebuilt.

The Air Furnace.—This furnace is still used in southeastern Missouri at a number of points, and to some extent in central Missouri. The form of the furnace is described in chapter VI. The practice is substantially the same as given in considerable detail by Prof. Williams in his report of 1877, so but little need be said here. The furnaces are usually built of stone, with a brick tiling, and have the following general dimensions :

Length of hearth.....	9 ft.	Length of grate.....	5 ft. 6 ins.
Breadth " "	3 "	Breadth of "	2 " 6 ins.
Area of hearth to that of grate as 2 to 1.			

The usual charge is 1500 pounds of ore. This is generally worked off in eight hours with the aid of two men. The slag, which carries from 40 to 55 per cent of metallic lead, is rarely re-treated, but is generally thrown away. Wood is the only fuel used, about a cord to the

ton of ore being an average consumption. The fact that weights are generally estimated, and that moisture is never considered, renders it practically impossible to arrive at any accurate figure concerning the yield of metal and the cost of smelting by this process. It is estimated, however, that the average yield is between 80 and 90 per cent, although with careful workmen it may be considerably less.

The following list comprises all of the furnaces of this kind now in operation in the state; many of these, however, are only run at intervals.

LIST OF AIR FURNACES IN MISSOURI.

Cole county, Woodworth, J. D.; $\frac{1}{2}$ mile east of Enon.

Franklin county, Bartle, J. N.; St. Clair.

Miller county, Miller Co. M. and S. Co.; 7 miles north of Tuscumbia.

St. Francois county, Taylor, W. R.; Taylor place.

Washington county, Flynn, J. & M. M.; Richwoods.

“ Higginbotham, Z. T.; Fertile.

“ Long, James; Potosi.

“ Long, William; Potosi.

“ Moran, Chas.; Richwoods.

“ Palmer Lead Co.; Palmer.

“ Shibboleth Lead Co.; Cadet.

“ Union M. and S. Co.; Old Mines.

“ White, Mrs. L. J.; Old Mines.

At Desloge, about five miles south of Bonne Terre, on the B. T. & M. R. railway, the Desloge Consolidated Lead company have recently erected two Flintshire furnaces and two modified Flintshires.

The Scotch Hearth.—The original form of the Scotch hearth was a rectangular well, with back and sides built of stones dressed to make cubes. These were afterward replaced by cast-iron cubes, about 7 ins. on the sides, the use of which preserved the furnace for a much longer time, as the lead oxide had no perceptible effect on the iron lining, while it corroded the stone very rapidly. This solid iron lining gave place later to a hollow iron jacket, as described in chapter VI, through which water was circulated, giving a furnace that could be used continuously without becoming too hot. It seems, however, that the continuous use of this furnace is not always desirable, and, under such circumstances, the additional first cost of the hollow casting and the expense of circulating water through it is unnecessary, and consequently, in some places, a return to the solid iron back has been made.

The following are the only furnaces of this type that are now in operation:

Granby Mining and Smelting Company, Granby, Newton County.—This company has three Scotch hearths of the American water-back type. The lead well is 28 by 24 ins., and 14 ins. deep. They mine the ore on their own lands and jig it in a steam plant; the cleaned galena is smelted by them, while nearly all the carbonate ore is sold. The charge is 7000 lbs. of ore, and it is worked off in eight hours. The blast is supplied by a Sturtevant blower. The slag is resmelted in a slag hearth.

Serage & Case, Grand Falls, Newton County.—This company has two hearths located at Grand Falls on Shoal creek, six miles south of Joplin. The furnaces are water-backed, and the well is about 20 or 30 ins. The charge is 3500 pounds of washed ore to each furnace, and is worked off in seven hours. The blast is furnished by a Root blower. The stacks are connected with a brick flue, about 500 ft. in length, in which particles carried off mechanically are deposited. They also have a small slag hearth where the slag is re-treated when a sufficient quantity has accumulated. They jig all their ore by hand at present, but intend to put in a steam plant for this purpose, and likewise increase their smelting plant.

The Valle Mining Company, Valle Mines, St. Francois County.—This company has been in operation since 1823. Log and ash furnaces were used until about 1850, when the Scotch hearth was introduced. At first, two Scotch hearths and one slag-hearth were built; but subsequently, the latter was altered to a Scotch hearth. The ore consists mainly of galena, of which considerable clean "block mineral" is mined, but also a large quantity of "wash ore," or galena with attached gangue of barite rock. Some zinc ore, mainly smithsonite, is also mined. This is picked, calcined and shipped to Carondelet. The "wash ore" is first heated in a reverberatory furnace at a light heat to decrepitate the barite, which then separates readily. The ore is then jigged by hand and the clean product goes to the Scotch hearth.

There are three of these hearths, of solid cast-iron "stones" or blocks, 7 ins. on a side. The well is 16 ins. square by 12 ins. deep. One tuyere, $1\frac{1}{4}$ ins. in diameter, furnishes the blast. The charge consists of 3500 lbs. of cleaned or block mineral, which is worked off in about seven hours, one smelter and a helper being employed on each furnace. The fuel used is charcoal and small billets of wood, about 5 bushels of the former and $\frac{1}{2}$ cord of the latter being used on each furnace per day. The yield of lead is said to be 75 per cent. The blast for the three furnaces is furnished by a No. 12 Sturtevant fan, using one cord of wood per shift. Three men are employed to crush the ore for the furnaces. The furnaces are run early in the morning, so that the charge may be completed before the heat of the day. The slag, which carries about 45 to 50 per cent of lead, is sold to the St. Joseph company or to the St. Louis Smelting and Refining company. The brand of lead made is known as "Rozier."

Bugg, J. P. and R. M., Potosi, Washington Co.—These parties have one Scotch hearth with solid iron lining. They smelt the ore mined on the McArthur Bros. land. This ore carries considerable barite, and is dressed by hand to about 65 per cent. The charge is 3500 lbs., and is worked off in seven hours. The furnace is only operated during a part of the time.

The Picher Lead Company.—The works of this company have been quite fully described on p. 207, so that only brief reference need be made to them here. They introduce an entirely new idea into the smelting of lead, namely: the taking advan-

tage of the fact that the Scotch hearth, when forced, will volatilize a considerable portion of the lead, especially if the blast be heated. The volatilized product, when properly purified, makes an excellent white paint. This company produced in 1892, 3220 tons of sublimed whitelead, and 11,690 tons of piglead.

The Cupola Furnace.—The cupola or stack furnace was first erected at Mine La Motte, and we will begin by describing the works of that company.

Mine La Motte Company, Madison Co.—The ore from the mine, after being carefully picked, goes to the dressing works, where it is concentrated from 10 or 12 percent to about 70 or 72 percent. The concentrates are then taken to the roasting furnace. These, of which there are three, are of the Freiberg pattern, 66 ft. in length and 12 ft. in breadth. Their capacity is about 15,500 lbs. each. Toward the end of the roasting, about 100 lbs of sand are added to each charge, and after the ore has become rather pasty, it is drawn. It is then charged into the cupola furnace with proper proportions of iron ore and limestone, and some roasted matte. The resultant products are pig lead, matte and slag. The ore contains a small amount of nickel and cobalt, which collects in the matte. This matte is roasted in kilns and recharged into the cupola, with succeeding charges of ore, and thus the nickel and cobalt are concentrated in it. It is then smelted in a smaller cupola furnace with an iron speiss, purchased for that purpose; the resultant speiss, containing about 18 percent of nickel and cobalt, is packed in barrels and shipped to Hamburg for further treatment.

The larger cupola furnace is circular, and is 45 ins. in diameter at tuyeres. It is provided with steel water-jackets, which have openings for five tuyeres. The shaft is of brick held in place by an iron plate $\frac{1}{2}$ inch thick. The crucible is 42 ins. in length and 43 ins. in diameter. The bosh extends from the top of the crucible to the ring plate, a distance of $6\frac{1}{2}$ ft. The total length of the furnace is 42 ft. The blast is furnished by a 40-horse-power engine, made by Naglok, Philadelphia; cylinder 3 ft. in diameter, with a 12-ft. stroke. The yield of this furnace in 24 hours, under normal conditions, is about 450 pigs, weighing about 82 lbs. each.

The "work" lead from the furnace is refined by melting in a large, hemispherical kettle, 6 ft. in diameter, which holds about 460 pigs. The lead is melted gradually, and is kept at a rather high temperature while the poling goes on, so that, being quite liquid, the impurities may more readily rise to the surface. The poling is accomplished by the admission of a jet of steam into the kettle, near the bottom, which agitates the contents and causes the foreign matter to rise to the surface and become oxidized. Some lead is also oxidized at the same time, and the "dross," as the skimmings are termed, is charged into the cupola furnace in small quantities with the charge. The lead is tapped, by means of a siphon, from near the bottom of the kettle, into the moulds, which are set on a circular revolving carriage. The contents of the kettle are cooled down as soon as possible when the lead is cast. These works produced 2500 tons of pig lead in 1893.

The St. Joseph Lead Co.—This company have their mine and mill at Bonne Terre, and also roast their ores there, while the remainder of their smelting plant is located at Herculaneum, about thirty miles north, on the Mississippi river. The ore is not

picked before milling, so that the average lead contents of the rock as it goes to the mill is not more than 6 or 8 per cent.

There are ten roasting furnaces at Bonne Terre, each 65 ft. long and 13 ft. wide; they are of the same general type as those in use at Mine La Motte. Each one has a capacity of about 10,000 pounds of ore per day. The ore, when roasted, is shipped to Herculanum, and there reduced in cupola furnaces. There are four of this type at Herculanum, three of which are in constant operation. They are circular in cross-section, about 40 ft. high and 50 inches in diameter at the tuyeres. They are provided with steel water-jackets. The bosh extends from the top of the crucible to the ring plate, as in the Mine La Motte furnace. The smelting operation is carried on in a similar manner, except that the matte, while roasted and recharged to save iron flux, is not saved and re-run for the nickel it may contain, the management declaring that the amounts of these metals are too small to pay expenses. Mill cinder is generally used for iron flux, instead of iron ores; this decreases the capacity of the furnace somewhat, by introducing a quantity of inert material that must be slagged off. The total output of these furnaces is between 800 and 1000 pigs per day, or about 38 tons of lead. The "work" lead is refined in a furnace much resembling a softening furnace. It is a small reverberatory, in which the lead is melted and poled with green wood. The "dross" is skimmed off and the lead cast into a line of moulds, working on a rack and pinion.

The Doe Run Lead Co.—This company was organized in 1886. The ore is similar to that mined at Bonne Terre, and is treated in a similar way. Formerly, their ore was smelted at Doe Run, but, about a year or so ago, arrangements were made with the St. Joseph Lead company whereby the ore roasted at Doe Run is reduced in the furnaces at Herculanum.

The St. Louis Smelting and Refining Works.—This company, situated at Cheltenham, a few miles west of St. Louis, has three cupola furnaces. Most of its supply of ores comes from the silver districts of the western states, and, though some of the ores mined within the state are mixed with these to facilitate the reduction, the quantity is not sufficient for the process to claim special consideration here; the outlines have already been given in chapter VI. A considerable quantity of the lead ores and slags produced in this state finds its way to the silver-lead smelters of St. Louis, Kansas City and Chicago.

Yields and Costs of Processes.—It will be noted by glancing over the subjoined table that the production of lead in this state is, with the one exception of the Picher company, pretty well limited to the cupola furnace.

AVERAGE ANNUAL PRODUCTION OF LEAD BY VARIOUS PROCESSES.

Air furnace	1,500 tons per year.
Scotch hearth	1,000 " "
Picher Lead works	11,700 " "
Cupola furnace	150,000 " "

This is not due to the lower cost of the last process, since figures indicate that it is quite as costly, if not more so than the others. The main reason is the necessity of pure and rich ores in the other processes.

The exact cost of smelting lead ores is very hard to ascertain. More particularly is this the case with the reverberatory and hearth processes, since, in these, the weighing out of the charge is very crude and is not checked in any way; no account is taken of moisture, and, often, the weigher errs on the side of generosity toward the smelter, who is obliged to make a certain turn-in or be docked in his pay. Thus, the cost per ton of ore smelted, or the yield of the ore, cannot be satisfactorily ascertained. The following figures, derived from information collected by Mr. Thacher and from the writer's notes, give a general idea of the cost of smelting.

COST OF OPERATING THE AIR FURNACE PER SHIFT.

Charge, 1500 tons cleaned ore; yield, 1200 lbs. lead, or 80 per cent.

1 smelter.....	\$1 50	½ roustabout.....	0 55
1 helper.....	1 30	½ cord wood.....	\$1 50
		Total	4 85

\$6.27 per ton ore; \$7.83 per ton lead.

COST OF OPERATING SCOTCH HEARTH PER SHIFT.

Charge, 3500 lbs. ore; yield, 2500 lbs. lead.

1 smelter.....	\$2 50	1 cord wood.....	\$2 00
1 helper.....	2 00	5 bus charcoal.....	40
1 engineer.....	2 50	wood billets.....	40
1 roustabout.....	1 00	Total	10 50

\$7.88 per ton of ore; \$9.80 per ton of lead.

The cost of smelting in the cupola furnace has been condensed, on account of the large number of items, to the cost per ton.

COST OF SMELTING IN CUPOLA FURNACE PER TON.

Ores are concentrates similar to those produced in southeastern Missouri, averaging 70 per cent metallic lead; loss assumed at 10 per cent.

Roasting ore.....	\$2 60	Cinder....	} Flux.....	{	99
Roasting matte.....	44	Iron ore....			08
Smelting in cupola.....	1 76	Wood			1 48
Refining	20	Repairs and supplies.....			1 18
Coke.	90	Total.....			9 61

\$9.61 per ton of ore; \$15.25 per ton of lead.

ZINC SMELTING.

It will be seen by referring to the list of zinc-smelting establishments in the United States, that those located in Illinois, Missouri and Kansas produced altogether in 1893, 65,597 tons of spelter, out of the total production of 76,255 tons. As the Wisconsin-Iowa mining district produced very lightly, by far the larger portion of ore which supplied the smelters of these three states came from Missouri (including the Galena camp in southeastern Kansas). This being the case, we shall include here a brief reference to various works outside of the State which subsist to a great extent on Missouri ores, as well as to those within the state boundaries. The process used is almost identical in every case with that described on pages 230-235, of chapter VI; thus only the special features of each establishment will be considered.

Illinois.

The Matthiessen and Hegeler Zinc company's works at La Salle are the largest in this state, as well as in the whole country. This company operates four large double furnaces, with a total of 2750 retorts. The furnaces are fired by gas made in producers, from coal mined by the company within the grounds of the smelting works. The blende is roasted and the gases evolved are converted into sulphuric acid, the company manufacturing about 45 tons of 66° acid per day. They produce about 13,000 tons of spelter annually.

The Illinois Zinc company's plant at Peru is another very large one. They have some 10 or 12 furnaces which are fired by gas as at La Salle, and produce about 10,000 tons of metal per year.

The Collinsville Zinc company, Collinsville, has four blocks of two furnaces each, all Belgian and fired directly. The total number of retorts is 1024, and their annual production is about 4000 tons of spelter. This company is using the Brown Horse-shoe furnace described on p. 232, to roast their ores, and say that it is doing excellent work.

The Wenona Spelter company, Wenona, have four Belgian furnaces, with 112 retorts each. They have been shut down since Sept. 1892. Their annual product was about 1500 tons.

Missouri.

The Glendale Zinc company, in the southern part of St. Louis, operates nine blocks of eighteen Belgian furnaces, with a total of 2070 retorts; they produce about 7000 tons of spelter annually. This company is putting in one of the Brown Horse-shoe furnaces for roasting. They formerly used the two-hearth reverberatory furnace.

The Empire Zinc company, Joplin.—This company uses the two-hearth furnace for roasting. They mine and dress the ore themselves, and are able, consequently, to keep it quite uniform in zinc contents. They have six furnaces of the Belgian

type, aggregating 644 retorts. These furnaces are fired directly. The output of the company is about 2900 tons per year.

R. Lanyon & Company, Nevada.—A four-hearth roaster is in use here, which is built over the Belgian furnace, and utilizes the heated gases to roast the ore, thus effecting quite a saving. The Belgian furnaces, of which there are ten, are fired directly. They have a total of 1120 retorts, and produce about 4000 tons of spelter annually.

The Rich Hill Mining and Smelting Company, Rich Hill.—This company has four Belgian furnaces, fired directly, with 480 retorts, and one double gas furnace with 288 retorts, giving a total of 768 retorts. The retorts in the gas furnace are longer than those in the other furnaces, and thus the capacity is greater. The works produce about 3000 tons of spelter annually.

Kansas.

The Pittsburg and St Louis Company, Pittsburg.—These zinc furnaces were erected in 1881. The five-hearth roasters are used, and are considered better than those with the two hearths. There are four double blocks, or eight Belgian furnaces, fired directly, with a total of 896 retorts. They produce about 3000 tons of spelter annually.

S. H. Lanyon & Bro., Pittsburg.—This company has three blocks or six Belgian furnaces with 112 retorts each, making a total of 672 retorts. They produce about 2500 tons of zinc.

Robert Lanyon & Company, Pittsburg.—Ten furnaces are operated by this company, which are rather smaller than the usual Belgian furnace. They have 96 retorts each, or a total of 960 retorts. They produce about 3500 tons of zinc annually.

W. & J. Lanyon, Pittsburg.—These gentlemen operate three blocks or six Belgian furnaces, containing in all 672 retorts. Their output is about 2500 tons.

The Granby M. & S. Company, Pittsburg.—This company mines its ore at Granby and Joplin, in Missouri, and ships it to the works here for treatment. The output is about 2500 tons.

The Cherokee Zinc Company, Pittsburg and Weir City.—Six blocks, or 12 Belgian furnaces, are operated by this company at Pittsburg, with 1344 retorts; and seven blocks, or 14 furnaces, at Weir City with 1568 retorts, thus giving a total of 2912 retorts. The average output from the two works is about 7000 tons of spelter annually.

The Girard Zinc Company, Girard.—Operate 12 furnaces with 112 retorts. Their annual output is about 5000 tons of zinc.

Notes.—It has been estimated that the manufacturing of one ton of metallic zinc requires about 3 tons of ore, 6 tons of coal and 700 lbs. of fire-brick and clay. It may be readily seen, therefore, that it is important that the smelting establishment be contiguous to coal fields, and on competing lines of railway. The system of firing the furnace by producer gas, and the use of the regenerative system, have been referred to. It may be mentioned here, however, that the use of this system of firing has not been found economical in the regions of

extensive coal mining immediately contiguous to St. Louis, or in those of southwestern Missouri and southeastern Kansas. In these regions, a large supply of very cheap slack is available, which is long-flaming and well adapted to direct firing, while for producers, a better quality and more expensive coal is necessary. The practice of utilizing the gases from the roasting of the blende for the manufacture of sulphurous or sulphuric acids, has not been followed in this country, except to a limited extent. It is probable that in small plants it would not be profitable, but where the amount of ore treated is sufficient to justify the expense of erecting acid chambers, a sensible reduction in the cost of production of metal, is noticeable.

LEAD AND ZINC MANUFACTURING INDUSTRIES.

The manufacturing enterprises of Missouri, so far as lead and zinc are concerned, are not in proportion to the mining and smelting industries.

Lead.—By far the most important manufactured product of lead is white lead. There are four large companies located in St. Louis who make this substance, namely: The Collier White Lead company, the St. Louis Lead and Oil company, the Missouri White Lead company and the Southern White Lead company. These companies use desilverized lead for corroding. The process in all the factories is substantially as described in chapter VI.

The total output of white lead in St. Louis amounts to about 18,000 or 20,000 tons annually. In addition to this, there is also made by these companies every year, about 900 or 1200 tons of litharge and red lead.

The Picher Lead company of Joplin, as previously referred to, manufactures about 3200 tons of sublimed white lead annually.

The manufacture of sheet-lead and pipe is also an important item. The process of manufacture is very simple, consisting, in the case of sheet, simply of casting the metal into a heavy slab, three or four inches in thickness, and of rolling it until the desired thinness is obtained. Pipe is made by pressing the nearly solidified lead through a hole in the end of a cylinder by hydraulic pressure. The hole has a core or die in the center, which fixes the internal diameter of the pipe. Sheet and pipe-lead are manufactured by a number of companies in St. Louis, among which may be mentioned the Collier White Lead company, the Missouri White Lead company, the Southern White

Lead company, L. M. Rumsey & Company, N. O. Nelson, as well as several other smaller establishments. About 7000 tons metal are consumed annually.

Shot is manufactured by two companies in St. Louis, and is not made in any other locality in the state. These companies, the Collier Shot Tower works and the St. Louis Shot Tower works, manufacture annually about 3500 tons of shot, which is about 40 per cent of the annual production of the United States. The process of manufacture is not complicated, and has been described on a previous page.

Besides these more important products of lead, many of the large machinery and supply companies make various articles, such as gaskets, sash weights, glaziers' lead, etc. Some lead is used in the manufacture of type metal, but, owing to the amount of old metal used, the consumption of fresh lead is hard to ascertain. There is also a small amount of lead used for the manufacture of babbit metal.

Zinc.—The manufacture and consumption of zinc in this state is not large. The main uses are for galvanizing sheet and cast iron, and barbed wire.

There are two companies in St. Louis engaged in the manufacture of galvanized iron, namely: the St. Louis Stamping company and the Bannantine Galvanized Iron Manufacturing company. The process consists in thoroughly cleansing the sheet-iron article which is to be coated, by immersing first in dilute sulphuric acid, then in dilute muriatic acid, then in clear water. It is next dried thoroughly and immersed in a bath of molten zinc, after which it is cooled rapidly and is finished off.

The first mentioned company manufactures galvanzied sheet iron, and also coal-hods, wash tubs, water-buckets, well buckets, etc. This company produces annually about 2500 tons of galvanized sheet iron, 12,000 dozen coal-hods, 7000 dozen wash-tubs, and varying numbers of other articles. About 450 tons of zinc are thus consumed each year.

The Bannantine Galvanized Iron Manufacturing company produce mainly galvanized sheet iron, although they make some galvanized architectural castings. They make about 2200 tons of galvanized sheet annually, and use about 400 tons of zinc.

Barbed wire is covered with a coating of zinc, much in the same way that the sheet metal is treated. It is manufactured by the Continental Wire company and the Consolidated Wire company, both of St. Louis. They manufacture about 15,000 tons of barbed wire annually, and consume about 450 tons of zinc.

Brass is manufactured to some extent in this state, but it is generally made in small quantities by innumerable small machinists and manufacturers. On this account, it is impracticable to give a full list of brass manufacturers. In St. Louis, brass is made for plumbers' fittings, engine castings and electrical fittings, by L. M. Rumsey & Company, Rumsey & Sikemeyer, N. O. Nelson, Moore, Jones & Company, Hoyt Metal company, Belleville Brass works, Western Brass Manufacturing company, M. M. Buck and many other smaller companies. These companies each use between 25 and 75 tons of zinc annually.

STATISTICS OF MINING.

By Arthur Winslow.

It would be of great value, could we present complete figures of productions of all the mines in the state; but this is unfortunately impossible. In fact, so poorly has the gathering and preserving of the necessary data been cared for in the past, that not only of no one deposit in the state can complete and accurate figures of its output be presented, but of comparatively few can even an approximately full statement be made. For a few recent years we have quite exact figures relating to most of the mines, and of a few mines we have figures applying to most of the years of their operations; but it was recognized from the start as altogether out of the question to prepare tables of the productions of all of the mines. Effort has, therefore, been confined to an attempt to give: 1) an estimate of the total productions of each county during successive periods since the time when mining first began within its borders; and 2) a statement, in tabular form, of the total productions of the whole state during similar successive periods or years.

County Productions.—The county statements which are presented, as can be gathered by accompanying notes, are of very variable value; some deserve to rank as close approximations; others, especially of the small-producing counties, are to be considered as surmises. Some display of the distribution of productions seems, however, to be called for, and we have made the effort in recognition of this call. Had time permitted, these statements might have been perfected in many details, but we doubt whether available records exist from which the general results could be much improved upon. In any case, the facts here presented may at least serve as a basis for others to build on.

In preparing the tables, use has been made of all facts heretofore published, as well as of all statistics collected by the Geological Survey. Details that have already been published in generally accessible volumes, are not generally reproduced here; but such as appear are principally the results of original inquiry, or exist in reports and

circulars of private or of a very limited distribution. In describing the counties the alphabetical order will be followed.

Prices of Lead and Zinc.—In addition to the tonnages given in the following tables, it will be noticed that the values of the productions are also included. For determining these values, prices prevailing during the several periods have been used, so far as they could be ascertained; inasmuch as it was out of the question to obtain the exact receipts from the sales of metals or ores.

In 1804, Austin states that lead was worth 5 cts. per pound. As the conditions of the western county were somewhat similar during the preceding century, and for lack of better information, this value is applied to the productions up to the year 1800, and for the first 10 years after that date. In 1819, Schoolcraft states that the metal was worth 4 cts. per pound at the smelters. In 1824, a report in the American State Papers states that the price of lead rose from 4 cts. to 6½ cts., and that in 1825 it was 5½ cts. per pound. For the years 1844 to 1873, the following table shows the prices of lead in St. Louis as given by Mr. Cobb [*32-p. 683*]:

PRICE IN CENTS PER POUND OF MISSOURI LEAD AT ST. LOUIS, 1844 TO 1873.

<i>Year.</i>	<i>Price.</i>	<i>Year.</i>	<i>Price.</i>
1844.....	3.02½	1859.....	5.25
1845.....	3.30½	1860.....	5.25
1846.....	3.42½	1861.....	5.25
1847.....	3.71	1862.....	6.50
1848.....	3.68	1863.....	8.62½
1849.....	4.07	1864.....	12.80
1850.....	4.60	1865.....	10.00
1851.....	4.28½	1866.....	10.00
1852.....	4.35	1867.....	9.00
1853.....	5.98	1868.....	9.00
1854.....	6.19	1869.....	8.75
1855.....	5.74½	1870.....	7.25
1856.....	6.22	1871.....	7.00
1857.....	6.00¼	1872.....	6.87½
1858.....	5.20	1873.....	6.87½

For the years 1874 to Nov. 1894, inclusive, we present the following table, prepared from information furnished by Mr. Geo. H. Morgan, secretary of the Merchants' Exchange, St. Louis:

TABLE OF AVERAGE MONTHLY AND YEARLY PRICES OF LEAD IN CENTS PER POUND
IN ST. LOUIS—1874 TO 1894.

	Jan.	Feb	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov	Dec.	Yearly Avg.
1874	6 60	7 10	6 75	6 50	6 60	6 00	6 05	6 20	6 00	6 25	6 55	6 60	6 34
1875 ..	6 65	6 70	6 50	6 35	6 30	6 50	6 50	6 75	6 80	7 00	7 00	7 00	6 70
1876	6 95	6 85	7 00	7 00	7 00	7 00	6 90	6 65	6 50	6 00	5 75	5 75	6 60
1877	5 75	6 00	6 25	6 15	5 75	5 35	5 15	4 75	4 35	4 05	4 15	4 10	5 15
1878	3 85	3 65	3 50	3 50	3 40	2 85	3 15	3 25	3 35	3 25	3 40	3 75	3 40
1879	3 95	4 25	3 60	3 45	2 95	3 45	3 90	3 85	3 75	4 50	5 40	5 50	4 00
1880	5 65	5 75	5 35	5 25	4 35	4 15	4 20	4 50	4 50	4 50	4 45	4 30	4 75
1881	4 35	4 50	4 45	4 35	4 50	4 25	6 55	5 00	5 20	5 05	3 75	4 85	4 10
1882	4 80	5 05	4 65	4 75	4 45	4 50	4 75	4 75	4 75	4 65	4 50	4 25	4 70
1883	4 25	4 25	4 20	4 20	4 15	4 10	4 15	4 00	4 05	3 05	3 65	3 30	4 00
1884	3 65	3 60	3 80	3 65	3 50	3 40	3 35	3 40	3 45	3 55	3 35	3 35	3 50
1885	3 50	3 50	3 50	3 45	3 45	3 60	3 95	4 05	4 15	4 05	4 10	4 30	3 80
1886	4 35	4 55	4 75	4 60	4 60	4 60	4 65	4 60	4 45	4 55	4 20	4 05	4 50
1887	4 11	4 20	4 25	4 05	4 30	4 40	4 50	4 47	4 25	4 10	4 25	4 60	4 30
1888	4 65	4 70	4 80	4 65	3 80	3 80	3 75	4 05	4 85	4 30	3 45	3 50	5 00
1889	3 50	3 45	3 40	3 40	3 60	3 80	3 75	3 65	3 75	3 60	3 60	3 60	3 60
1890	3 60	3 60	3 75	3 75	3 65	4 25	4 30	4 50	4 85	5 20	4 70	4 05	4 20
1891	4 20	4 10	4 10	3 95	4 10	4 25	4 25	4 30	4 30	4 15	4 00	4 05	4 15
1892	3 90	3 95	3 95	4 05	4 05	4 00	4 00	3 95	3 85	3 75	3 60	3 60	3 90
1893	3 60	3 70	3 70	3 90	3 80	3 50	3 25	3 05	3 55	3 25	3 20	3 10	3 50
1894	3 00	3 05	3 10	3 20	3 15	3 10	3 20	3 25	3 00	....	....	....	....

The spelter made from Missouri ores is controlled by New York prices, and for these we refer to the table in chapter VI, p. 260.

Prices of Ores.—The values of the ores given in the tables are intended to be at the mines Brackenridge, writing in 1811, states that the ore delivered at the pit sold for from \$20 to \$25 per 1000 pounds [28, p. 149]. In 1819, Schoolcraft states that the miner got \$40 per ton for lead ore at the smelter.* The Land Office reports of 1825 state that the miner received 800 pounds of lead for one ton of ore, which, at the average price of 5 cts. per pound for lead, was equiva-

*As the furnaces at this time were in close proximity to the mines, this is practically the value at the mine.

lent to \$40 per ton of ore. Hodge, writing in 1842, implies that the price of lead ore in Missouri was \$36 per ton. The low price of lead about this time accounts for this diminution in value of the ore. In 1854, Swallow writes that the ores of southwestern Missouri were worth about \$40 per ton; but, in 1858, he notes the Granby lead ore as selling for \$32 per ton; but this was probably largely carbonate. For the years 1860 to 1870 we have obtained no figures of the prices of ore, but it must have risen along with the rise of the price of the metal, and, similarly, between the years 1870 and 1880 the two must have fallen together. The Tenth Census places the average value of lead ore for the whole state in 1880 at \$52. The Eleventh Census gives the average value for 1889 as about \$35.

Zinc ores, according to notes furnished us by Mr. H. Engelmann, secretary of the Matthiessen & Hegeler Zinc Co., were bought in the fall of 1873 at about \$8 per ton of blende, delivered on the cars at Baxter Springs. The price soon advanced to \$10, \$11 and \$14. After this the following prices were paid on an average:

In May, 1879.....	\$12 00
“ 1880.....	15 00
“ 1881.....	15 25
In Jan. 1886 (about).....	21 00
In 1888 (for several months, about).....	27 00

The average value given by the Census for 1880 was \$18.

During the years 1889 to 1893 inclusive, quite complete figures of receipts from sales of ores in different counties have been collected by the state mine inspector. From his returns we have compiled the table on the next page. In addition to giving the prices for these several years, this table will also enable one to establish a general ratio between the values of the ores mined in the different counties:

Metallic Yield of Ore.—In the statistical tables which follow, yields of both metal and ores are expressed. In some cases, as is indicated, metallic returns were received; in other cases the returns have been in ores. For converting the one into the other, it was necessary to establish certain ratios between tons of ore and of metal. The percentages of metal which have been actually derived from Missouri ores as they have been put into the furnace, can be determined only approximately. Actual returns of weights of ore used and of metal produced are only obtainable through special and critical inquiry, and such results, of course, only apply for the ores and furnace practice in use

TABLE OF AVERAGE VALUES OF LEAD AND ZINC ORES IN MISSOURI DURING THE YEARS 1889 TO 1893 INCLUSIVE.

Values expressed in dollars per ton at mine

Counties.	U. S. cen- sus	Lead Ores per ton.						U. S. cen- sus	Zinc Ores per ton.					
	1889.	1889.	1890.	1891.	1892.	1893.	Aver- ages	1889.	1889.	1890.	1891.	1892.	1893.	Aver- ages.
Barry .....	.....	.....	.....	.....	46	.....	46.00	13	13	20	17	16	.....	15.80
Christian .....	.....	.....	40	40	.....	.....	40.00	.....	.....	16	24	.....	.....	20.00
Cole .....	.....	.....	.....	44	46	.....	45.00	.....	.....	.....	.....	.....	.....	.....
Dade	43	45	.....	48	30	.....	41.50	13	12	11	11	10	6	10.50
Franklin .....	.....	.....	.....	44	42	.....	43.00	.....	.....	.....	.....	.....	.....	.....
Greene	28	41	44	48	46	.....	41.60	25	20	18	19	22	.....	20.80
Jasper	42	46	45	49	46	42	45.00	23	24	25	23	23	22	23.30
Jefferson .....	.....	53	36	43	46	34	42.00	.....	12	13	15	13	9	12.54
Lawrence	39	42	44	52	43	43	44.30	17	14	15	15	16	18	15.00
Madison	26	.....	.....	.....	43	48	39.00	.....	.....	.....	.....	.....	.....	.....
Moniteau .....	.....	.....	40	46	.....	.....	42.50	.....	.....	.....	23	.....	.....	23.00
Miller .....	.....	.....	.....	50	46	.....	48.00	.....	.....	.....	.....	.....	.....	.....
Morgan .....	.....	.....	20	.....	.....	.....	20.00	31	31	.....	23	.....	.....	23.35
Newton	42	41	50	47	43	40	43.80	23	20	20	18	21	13	19.20
Perry .....	.....	.....	.....	45	25	.....	35.00	.....	.....	.....	.....	.....	.....	.....
St. Francois ..	33	.....	.....	.....	43	36	38.70	10	.....	.....	.....	.....	.....	.....
Washington ..	26	40	45	48	46	32	39.70	.....	10	.....	.....	.....	.....	.....
Averages	35.25	44.00	40.45	47.45	42.45	39.29	40.91	19.35	20.90	17.90	18.80	17.30	13.60	18.85

at the time of investigation. For the year 1876, we have somewhat exact data in the Industrial Report of Prof. C. P. Williams. For other times we have had to depend upon recorded expressions of opinion of variable value. They are mostly based upon general observations, and are, hence, of only general applicability. The ratios used have been, in all cases, taken to represent the equivalent of metal contained in the ores as they are charged into the furnace; they do not refer to ores as extracted from the mine before they have been crushed or dressed; in other words, the concentrated ore is meant.

The sources of such information we will now proceed to enumerate. The first record we have is in Austin's letter of 1804, in which he states that, at the time of his coming to Missouri, in 1797, the old log furnace yielded only about 35% of lead. Brackenridge, in 1811 [28, p. 150], however, estimates the yield of the log furnace at 50%, and that of the

ash furnace at 25% to 30% more. Schoolcraft, writing in 1819, says that, under the Spanish rule, before the year 1800, not over 50% of the lead in the ore was obtained; at the same time, he gives the yield of the log furnaces then in use as 50%. As similar log furnaces were in use previous to the year 1800, and as the principal improvement which Austin made was the introduction of the ash furnace, we are inclined to think that the 50% yield given by Brackenridge and Schoolcraft is a closer approximation than the 35% of Austin. We have, hence, adopted this ratio for the 18th century.

In 1802, Austin writes that the massive ores from Mine a Burton yielded 60% in the common furnace and 15% more in the slag furnace, while "gravel" mineral did not produce over 60%, when cleanly smelted. In estimating the production of Mine a Burton and Old Mines, at this time, Austin allows an average of 66½%.

For the year 1819, we have already quoted Schoolcraft's figures, which allow a total yield of 65%. This, as he states, was, of course, variable, and dependent upon the care taken and skill exercised in the dressing and smelting of the ores. At this time, some attempts had been made to extract lead from the slag of the ash furnace, but they were not generally successful.

In 1823, returns published in the American State Papers give 60% as a general average yield, though as much as 70% was sometimes produced. In the same publication for 1825, an average yield of 62% is allowed.

In 1836, the Scotch hearth was introduced and slag furnaces were in use at some places. Dr. Litton, in treating of furnace yields between the years 1839 to 1854, allows uniformly 70% for the metal produced. In 1873, Messrs. Lloyd and Bauman, in calculating the metal contents of ores of southwestern Missouri, allow an average of 66½%.

In 1876, Prof. Williams gives as the yield of Missouri reverberatory furnaces 63%, while 9% more was contained in the residues from such furnaces, part of which was recovered in the slag furnace. Hearth furnaces gave 67%, and a few more per cent were obtained from their residues. For the years 1870 to 1893, Mr. J. P. Neville, president of the Granby Mining and Smelting company, states that the average yield of the Newton county lead ores can be placed at 70%. For the year 1880, the figures of the Tenth Census show an average return of 72% of lead from the ores smelted in Missouri. For the year 1889, the Census returns from Illinois, Missouri, Kansas and Wisconsin smelters

give a yield as low as 61.24% of lead. Mr. Arthur Thacher reports, however, that the average yield with present practice in southwestern Missouri is about 70%.

The yield of zinc ore applies only to the last 20 years, and it might be supposed that very satisfactory data could be obtained. This is, however, not the case. The quality of the ore varies greatly. While with lead, galena is almost the sole ore, with zinc the carbonate and silicate constitute large proportions of the shipments; these lose different amounts in calcination, ranging from 2% to 14%, and, further, their yield is more affected by the skill of the smelter than is the case with lead ore. Mr. Engelman, of the Matthiessen & Hegeler Zinc company, gives a rough guess that Missouri blende will make from 40 to 46% of spelter. The yield from the silicate and carbonate ores will average perhaps about 33%. Mr. Neville allows 33½% for Granby ores. The Tenth Census shows a return of 33% of spelter from Missouri zinc ores, ⅔ of these being classed as silicate. The Eleventh Census for 1889 shows a yield of 55% of spelter from the ore treated. This must, however, be a mistake, as the zinc ore treated from the immediately adjoining area of Kansas is allowed only 33%.

Based upon these data, we have prepared the following average prices and yields, which have been used in calculating the succeeding production tables.

TABLE OF AVERAGE PRICES AND YIELDS OF LEAD AND ZINC AND THEIR ORES IN MISSOURI.

	Prices.					Yields.		
	Lead.		Zinc.			Lead.	Zinc.	
			Blende.		Silicate.			
	Ores.	Metal.	Ore.	Metal.	Ore.	Galena.	Blende.	Silicate.
	Dollars per ton.	Cents per pound.	Dollars per ton.	Cents per pound.	Dollars per ton.	Per cent.	Per cent.	Per cent.
1720-99.....	40	5.0	.....	.....	.....	50	.....	.....
1800-19.....	40	4.5	.....	.....	.....	60	.....	.....
1820-29.....	40	5.0	.....	.....	.....	62	.....	.....
1830-49.....	40	4.5	.....	.....	.....	65	.....	.....
1850-59.....	40	5.4	.....	.....	.....	70	.....	.....
1860-69.....	60	8.5	.....	.....	.....	70	.....	.....
1870-79.....	50	5.9	12	6.0	10	70	40	33
1880-93.....	43	4.1	22	5.0	12	70	43	33

COUNTY PRODUCTIONS OF LEAD AND ZINC.

The following county tables and accompanying notes are arranged in alphabetical order. Original figures are marked with an asterisk (*); figures calculated from these are without asterisk. Values of metallic lead are based upon St. Louis prices; values of metallic zinc upon New York prices. Values of ore are based upon recorded prices paid for ore at different dates, and also upon the market price at the time. Ratios between metals and ore are based upon the average furnace yield of the given period, so far as can be determined.

Barry County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons</i>	<i>Values.</i>	<i>Tons</i>	<i>Values.</i>	<i>Tons</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
Before 1880.....	10*?	\$500	7	\$826	.....	.....	.....	.....
1880 to 1893.....	150*	6,450	105	8,610	1,200*	\$14,400	400	40,000
Totals.....	160	6,950	112	9,436	1,200	14,400	400	40,000

The available facts relating to the productions of Barry county are very few. Some mining was apparently done there before the war, and in 1858 Swallow locates one mine in the northeastern corner. From that time up to recent years we have no information. There is no reference to Barry county in the returns of the census of 1870 or 1880. In 1888, the Drake or Henderson mine was opened near Purdy, and some blende and silicite were produced; according to figures given the Survey, the output amounted to 525 tons of zinc ore up to 1891. The same year the Kelly and Anderson mines were opened, and a little zinc and lead ore was dug. The Northwest lands were not worked until 1891, though ore had been discovered here as early as 1878. In the same year, the Allen & Stark, the Martin, Claycomb & Jones, Stanberry, McDowell and a few other mines were opened; they did not produce more than a few tons altogether, however. The following is a statement of the shipments of the Purdy mine from June, 1888, to January, 1891, inclusive, as appeared in a Barry county paper; they are presumably of zinc ore entirely.

OUTPUT OF THE PURDY MINES.

<i>Years.</i>	<i>Tons.</i>	<i>Years.</i>	<i>Tons.</i>
1888.....	153	1890.	223
1889.....	105	1891 (January).....	15
		Total.....	476

The Eleventh Census credited the county in 1889 with 180 tons of zinc ore, valued at \$2340. The productions of the county, according to the state mine inspector, for the years 1889 to 1893, inclusive, are as follows:

LEAD AND ZINC DEPOSITS OF MISSOURI.

PRODUCTION OF LEAD AND ZINC ORE IN BARRY COUNTY.—YEARS END JUNE 30.

Year.	Lead ore.	Zinc ore.	Year.	Lead ore.	Zinc ore.
1889.....	none	180 tons—\$2,340	1892	84 tons—\$3,864	192 tons—\$3,089
1890	“	30 “ 600	1893.....	none	none
1891.....	“	525 “ 9,125	Totals.	84 3,864	927 15,154

In addition, Mr. J. G. Mariot, of Purdy, furnishes the following table:

	Opened	Operated up to	Production tons ore.		Opened.	Operated up to.	Propuction tons ore.
Dodgemine	1898	1892	90 L. & Z.	The Dowell	1892	1893	22 L. & Z.
Henderson mine	1888	1892	1000 Z	Rathbone & Hill	1888	1889	10 L.
Pioneer mine....	1890	1893	100 L & Z	Sugar Camp ...	1889	1893	5 L.
Allen & Stark ...	1890	1893	50 Z.				

On the basis of these facts, we feel warranted in saying that before the year 1880 only a few tons of lead ore were produced in the county, and since that time the production has not exceeded 150 tons of lead ore and 1200 of zinc ore.

Benton County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	Tons.	Values.	Tons.	Values	Tons.	Values.	Tons.	Values.
Before 1870.....	150*	\$9,000	105	\$17,850	.....	.....	.....	.....
1870 to 1874.....	250*	12,500	175	20,650	10*	120	4	480
Totals.....	400	21,500	280	38 500	10	120	4	480

In 1843, the Cole Camp mines were discovered, but mining does not seem to have been begun until 1848, when it is reported that considerable ore was taken out. In 1859, operations were resumed, and 25 tons of ore were mined. In the same year, the White diggings were opened, but up to 1874 they yielded only five tons of ore. There is no reference to Benton county in the census returns of 1870, nor in those of the 10th and 11th Census of 1880 and 1889. The State Survey report describes five mines in 1874, of which two had mined to that date eight tons. No production of ore from Benton county appears in the Mine Inspector's reports for 1889 to '93. In 1891, Mr. Robertson visited the Haldeman mine, which, up to that time had produced a few tons of blende.

Mr. George Kieffer, of Cole Camp, furnishes the following table of productions:

Melton No. 1 (Cole Camp). Worked in 1861 and before	100 tons
Melton No. 2. Worked about 1878	50 “
Leischel, worked about 1878.....	100 “
Scattered workings about 1878.	25 “
Total	275 “

Major R. H. Melton is of the opinion that these estimates are too low, and states that the Cole Camp mine No. 1 produced 150 tons of lead before the war. In another communication he says that from these Melton or Cole Camp mines millions of pounds of lead were taken out, and zinc ore, and large quantities of lead were raised at other points. From these imperfect and conflicting data we have estimated the figures given in the table.

Camden County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1846 to 1849	100*	\$1,000	65	\$5,850	.....	.....	.....	.....
1850 to 1859	200*	8,000	140	15,120	.....	.....	.....	.....
1860 to 1869 .....	.....	.....	.....	.....	.....	.....	.....	.....
1870 to 1879	400*	20,000	280	33,040	.....	.....	.....	.....
1880 to 1893	300*	.....	.....	.....	.....	.....	.....	.....
Totals	700	32,000	485	54,100	.....	.....	.....	.....

A furnace was erected in Camden county in 1846, and presumably started soon after. In 1852, Ex-Governor McClurg informs us, about 100 tons of ore were taken from a shaft less than half a mile from Linn Creek, and smelted there. Other work must have been done there during preceding and succeeding years. Between 1860 and '69 we have no records of work. In the years 1874 and '75, Gov. McClurg states that about 150 tons of ore were smelted in Camden county. According to the Geological Survey report, there were seven mines and one furnace in operation in 1874. No productions of ore or lead are credited to Camden county in the reports of the 9th, 10th and 11th Census or in the State Mine Inspector's reports for 1889 to '93.

Near Toronto, in the southeastern corner of the county, mining was begun about 1875, and continued until 1886. About 100 tons of lead were mined. A furnace was built in 1876, which smelted a good deal of Linn Creek ore in latter years.

Christian County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1850 to 1859	200*	\$8,000	140	\$15,120	.....	.....	.....	.....
1860 to 1869	300*	18,000	210	35,700	.....	.....	.....	.....
1870 to 1879	3,000*	150,000	2,100	247,800	.....	.....	.....	.....
1880 to 1893	2,000*	86,000	1,400	114,800	500*	\$6,000	165	\$16,500
Total	5,500	262,000	3,850	413,420	500	6,000	165	16,500

As far back as 1819, Schoolcraft refers to the existence of lead ore on the James river. The first notice of mining which we have is, however, nearly 40 years later. Thus, in 1858, Swallow tabulated 12 mines in Christian county, of which 5 were worked; there was also one furnace in operation. Of these mines, Price and Bray's was the largest, and had yielded, up to June, 1857, 85 tons of ore. The mines of Elk valley, near Ozark, were also started about this time. From 1850, to 1859, we have allowed the production of 200 tons of ore. It is possible that something was produced before this, but we have been able to obtain no clue as to the amount.

During the next 10 years, more or less mining was prosecuted in the county, partly by the Confederates during the war. No figures of production are obtainable, and the 300 tons introduced by us is entirely an estimate.

The Census of 1870 contains no mention of Christian county, but soon after this, mining was resumed with profit. Harper's mine was discovered in 1873. Between 1873 and 1875 the Alma mines were extensively worked, some 300 men being employed at one time. According to one estimate, obtained by Mr. Robertson, they have yielded 2,500 tons of lead to date. As a further contribution to the production of this period, we insert the following table, kindly furnished us by Mr. John C. Rogers, of Ozark:

	<i>Years opened.</i>	<i>Years worked.</i>	<i>Tons of ore.</i>
Alma mine	1875.....	1875 to 1879	1,500
Bray mine	1872.....	1876.....	400
Swan Creek.....	1872.....	1877.....	500

In 1880, the Tenth Census credits Christian county with 432 tons of lead ore and no zinc ore. For 1889, neither the Census nor the State Mine Inspector's report contains mention of Christian county. For the next two years the Mine Inspector gives the following figures:

PRODUCTIONS OF CHRISTIAN COUNTY—YEARS END JUNE 30.

	<i>Lead ore.</i>	<i>Zinc ore.</i>
1890 ..	30 tons=\$1,200.....	100 tons=\$1,600
1891	20 " 800.....	40 " 960
1892 and 1893.	No production given.	

Cole County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
Before 1840.....	100*	\$4,000	60	\$5,400	.....	.....	.....	.....
1840 to 1849.....	400*	16,000	265	23,400	.....	.....	.....	.....
1850 to 1859.....	300*	12,000	210	22,680	.....	.....	.....	.....
1860 to 1869	100*	6,000	70	11,900	.....	.....	.....	.....
1870 to 1879.....	2,500*	125,000	1,750	206,500	.....	.....	.....	.....
1880 to 1893	500*	21,500	350	28,700	.....	.....	.....	.....
Totals.....	3,900	184,500	2,705	299,030	.....	.....	.....	.....

As early as 1820, lead ore was discovered in southern Cole county, and a lead furnace was built in 1827 by a Mr. Chouteau, of St. Louis. Of the amount produced, we have, however, no record. In 1840, the old Circle diggings were opened and were worked at intervals during the next 20 years, and again later. In 1874, the report of the Geological Survey gives the total production of this mine as 700 tons. Of this, probably 400 were produced before 1850, and perhaps 200 more before 1860. In 1869, ore was obtained at the Old Circle and Fowler diggings, amounting perhaps to 100 tons.

In 1870, the Census does not include Cole county among the lead producers of the State; but, by 1873, according to the report of the Geological Survey, there were 20 openings operated and two furnaces running, yielding 1600 tons of ore for the three years—1872 to '74. In 1876, there were four furnaces in the county.

The Census for 1880 credits the county with only 30 tons of lead ore, and that for 1889 contains no mention of it. No figures are given in the Mine Inspector's report excepting for the years 1891 and '92, when the following are presented:

Year.	Tons lead ore.
1891	46=\$2,024.
1892	35=\$1,610.

It is well known that the maximum period of activity was between 1872 and 1878; since that time mining has been prosecuted in a desultory way, and probably the rate of the last few years is about what has prevailed since 1880.

Shipments from Cole county, as furnished by the Mo. Pac R'y Co., are as follows in tons:

Year	Oaage.	Elston.	Russellville.	Year.	Oaage.	Elston.	Russellville.
1877..	998 pig lead.	.....	.....	1881.	.....	10 pig lead.	.....
1878..	1,314 "	.....	.....	1882.	.....	.....	20 lead ore.
1879..	.....	80 pig lead	.....	1887.	.....	.....	40 "
1880..	1,279 "	30 "	.....			

Part of this was doubtless derived from Camden, Miller, Morgan and other counties.

Cooper County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	Tons.	Values	Tons.	Values.	Tons.	Values.	Tons.	Values.
Before 1870.	30*	\$1,800	21	\$3,570	.....	.....	.....	.....
1870 to 1879.....	100*	5,000	70	8,260	.....	.....	.....	.....
Totals	130	6,800	91	11,830	.....	.....	.....	.....

In 1844, the old Scott diggings were first worked, but by 1854, Swallow states that only about 3 tons of galena had been obtained. Mining was prosecuted only in a desultory way, however, and, hence, we consider the allowance of 30 tons before the year 1870, a fair one. In 1870, the Census credits the county with the production of about 8 ton of ore, valued at \$300.

In 1871, an air-furnace at the Scott diggings smelted about 15 tons of lead. In 1873, the Collins diggings were opened, and about 12 tons of ore were mined by 1874. At this time there were two mines and two furnaces in operation in the county. Since that time we have no records of production. No figures are given in the Census for 1880 or 1880, or in the Mine Inspector's reports for recent years.

Crawford County.

Period.	Lead.				Zinc.			
	Ores.		Metals.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1830 to 1849	500*	\$20,000	325	\$29,250	.....	.....	.....	.....
1850 to 1859	1,000*	40,000	700	75,600	.....	.....	.....	.....
1860 to 1869	400*	24,000	280	47,600	.....	.....	.....	.....
1870 to 1879	600*	30,000	420	49,560	.....	.....	.....	.....
1880 to 1893	200*	8,600	140	11,480	.....	.....	.....	.....
Total	2,700	122,600	1,865	213,490	.....	.....	.....	.....

Mining began in Crawford county at Mineral Hill and Hulbert's mine in 1837. The Fort diggings were opened in 1840. The Williams mines were opened in 1857, and from that time until 1860 this and other mines were worked extensively. Up to 1854, according to Shumard, 200 tons of ore had been produced at the Williams mines. Up to 1856, the Mineral Hill mines had produced 500 tons of ore. Up to 1867, twelve other mines, according to Shumard, had produced about 300 tons of lead ore. From the figures given by Dr. W. A. Metcalf, and quoted in detail under the mine descriptions, it appears that between 1858 and 1890 some 12 mines produced about 1200 tons of lead ore. The Fort mine had produced 150 tons of ore from the beginning of operations.

This is, in general terms, all the information which we have relating to Crawford county productions. No figures are contained in the Census reports, nor in the Mine Inspector's reports to date.

Dade County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1870 to 1879	1,500*	\$75,000	1,050	\$123,900	8,000*	\$80,000	2,665	\$319,800
1880 " 1893	641*	7,563	449	36,818	5,000*	60,000	1,665	166,500
Totals	2,141	102,563	1,499	160,718	13,000	140,000	4,330	486,300

Mining in Dade county is, comparatively, of quite recent date. The first record of shipments which we have is in 1874, when Matthiessen & Hegeler obtained 536 tons of carbonate of zinc from Dade county, and in 1875, 733 tons more. The Corry Mining company or the Dade County Mining and Smelting company furnished 149 tons of lead ore in 1875; up to 1877, this company shipped about 1000 tons of lead ore and 5000 tons of zinc ore, principally carbonate; since that time little work has been done. Between 1875 and 1878, according to notes of Prof. C. P. Williams in the Survey office, Old mine in this county produced 1000 tons of silicate and carbonate of zinc.

In 1880 the Census gives 48 tons of lead ore and 251 tons of zinc ore as the county production. For the years 1881 to 1892 the following valuable table, kindly furnished by Mr. J. S. Ford, comptroller of the K. C., F. S. & M. R. R. company, shows the shipments:

SHIPMENTS OF LEAD AND ZINC ORES AND METALS OVER THE K. C., F. S. & M. R. R.

Year.	South Greenfield.	Everton.	Year.	South Greenfield.	Everton.
1879			1886	7 cars	8 "
1880			1887	3 "	
1881	2 cars	7 cars	1888	3 "	7 "
1882	8 "	44 "	1889	10 "	28 "
1883		38 "	1890	48 "	24 "
1884	2 "	5 "	1891	19 "	2 "
1885	3 "	5 "	1892	8 "	2 "
				113	170

The production of the county for the past 5 years is given by the Eleventh Census and the State Mine Inspector as follows:

Eleventh Census.	Lead ore.	Zinc ore.
1889	76 tons=\$3,240.....	153 tons= \$1,308
Mine Inspector—(years ending June 30).		
1889	55 tons=\$2,460.....	174 " 2,088
1890		1,647 " 17,296
1891	87 " 3,200.....	1,274 " 13,646
1892	99 " 2,962.....	163 " 1,067
1893		220 " 1,320
Totals.....	241 9,622.....	3,418 35,417

*The average weight of a car load is given by the company as 17½ tons of 2,000 pounds.

Dallas County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	Tons.	Values.	Tons.	Values.	Tons.	Values.	Tons.	Values.
1868 to 1869	500*	\$30,000	350	\$59,500	.....	.....	.....	.....
1870 to 1879	100*	5,000	70	8,260	.....	.....	.....	.....
1880 to 1893	100*	4,300	70	5,740	.....	.....	.....	.....
Totals.....	700	39,300	490	73,500	.....	.....	.....	.....

The principal, and almost only, noteworthy mine in Dallas county is the Rambo. This was operated between the years 1868 and 1870, and 500 tons of ore were produced. North of this, about Lead Mine postoffice, are the Hildebrand and Nassalrod diggings, which produced some ore during past years. Recently, small openings have been made about the county seat, Buffalo; in O'Bannon prairie, in the southern part of the county, considerable quantities of ore are reported to have been dug in the last few years.

Franklin County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
Before 1820	50*	\$2,000	30	\$2,700	.....	.....	.....	.....
1820 to 1829	100*	4,000	62	6,200	.....	.....	.....	.....
1830 to 1849	16,000*	640,000	10,400	936,000	.....	.....	.....	.....
1850 to 1859	9,300*	372,000	6,590	703,080	.....	.....	.....	.....
1860 to 1869	3,000*	180,000	2,100	357,000	.....	.....	.....	.....
1870 to 1879	5,000*	250,000	3,500	413,000	.....	.....	.....	.....
1880 to 1893	4,000*	172,000	2,800	229,600	.....	.....	.....	.....
Totals	37,450	1,620,000	25,402	2,647,580	.....	.....	.....	.....

The earliest lead mining in Franklin county which we have reference to, was at the Thomas mine, during the last part of the 18th century; but there are no records of early production. About the year 1828, lead ore was dug and smelted on the school lands of the county and Litton states that some 32 tons of ore were produced about this time. In 1830 the Gelconda mine was discovered and mining was begun; it was worked again in 1854, 6 tons of ore being produced in 4 months. In 1834 the Virginia mine was opened, and was apparently worked up to 1846, but after that, little was done until 1854; it was worked on lease to 1873, and produced up to that time, according to Col. A. W. Maupin of Union, about 12,500 tons of ore; it was then bought by a company, and since has yielded about 625 tons. Other mines were opened between 1830 and 1850, but we have few details as to their production. Dr Litton gives the following figures of some of the mines:

PRODUCTIONS OF SOME FRANKLIN COUNTY MINES UP TO 1854.

	<i>Tons ore.</i>		<i>Tons ore.</i>
Evans mine	100	Mt Hepe, including a small quantity from the Stort and Cove mines, 1849-54	974
Darby	65	Other mines	220
Hamilton	50	Virginia mine	5,000
Massey	2	Total	6,461
Barthold	50		

In 1870, the U. S. Census values the lead product of Franklin county at \$27,630, which is approximately equal to 600 tons of ore. The Census of 1890 credits the county with a production of 215 tons of ore; the Census of 1899 has no reference to the county.

In addition to the above information, Col. Maupin has supplied us with the following estimates of productions of the mines of the county up to 1892. These are derived from his knowledge of their history, based upon a residence of forty years in the county and association with its mines, and also upon recorded furnace yields.

TOTAL PRODUCTIONS OF FRANKLIN COUNTY MINES UP TO 1892.

	<i>Tons ore.</i>
Thomas mine, since 1840	7,500
Hamilton, Patton & Eliot mines	2,000
Shotwell mine (1887 and 1888)	750
Peninsula mine, operated principally from 1898 to '63, and very little since 1875; this and the Stahlmann, Newell and Highland mine adjoining, over.	1,000
Jack mine and the Union Land Co. and Wengler mines adjoining, about.....	250
Clark, Appleton, Herrington, Gallisher, Booth, Jeffries and Pickel mines.....	1,250
Golconda.....	750
Mt. Hope, Cove, Caswell and Evans mines, and the North and South Virginia mines...	8,000
Northumberland mines.....	1,000
Petroleum lead mines	625
Silver lead mines	750
Giles mine, about	150
Glard, Barthold or Jeffries, Massey, Wood & Gallenkamp, and other contiguous mines	50
Virginia mine	18,125
Total	37,200

In addition, Col. Maupin furnishes the following valuable table of furnace and mine productions since 1873:

FURNACE AND MINE PRODUCTIONS, 1873 TO 1891 INCLUSIVE.

	<i>Tons lead.</i>		<i>Tons lead.</i>
Moselle furnace.....	400	Stanton & Gallegar.....	50
Evans	150	Hartlein & Lesueur	5
Silver lead furnace	100	Peninsula mine.....	20
Caswell "	125	North & South Virginia mine	62
Northumberland furnace.....	4,560	Piney mine	13
Virginia L. M. Co.....	300	Harmon mine.....	49
Shotwell M. Co.....	775	Campbell "	1
Flynn & Long furnaces shipped or hauled from Franklin to Washington county.	250	Skinner "	12
Otto & Fragee mine.....	100	Chiles "	8
Thomas mine (Rueppela)	175	Highland M. Co.....	25
Binabacher mine.....	50	Darby (Jeffries & Stillbrink).....	22
Hamilton "	125	Mt. Hope and Cove mines	38
Patton "	87	From all other mines I would estimate at least	25
Elliott	38	Total	7,590
Wengler.....	25		

For the year 1891, the State Mine Inspector credits the county with a production of 231 tons of ore, valued at \$10,164; for 1892 the figures are 150 tons of ore, valued at \$6300; for 1893 there are no figures given. From these data we have prepared the statement given in the table.

LEAD AND ZINC DEPOSITS OF MISSOURI.

Greene County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
Before 1870	300?	\$18,000	210	\$35,700	.....	.....	...	.....
1870 to 1879.....	5,000*	250,000	3,500	413,000	200*	\$2,400	80	\$9,600
1880 to 1893..	4,100*	176,300	2,870	235,340	5,500*	121,000	2,365	236,500
Totals.....	9,400	444,300	6,580	684,040	5,700	123,400	2,445	246,100

The existence of lead on the James river, referred to by Schoolcraft in 1819, was of interest to Greene county as well as to Christian county. It was apparently mined here soon after this, and, in 1844, ex-Governor McClurg bought ore from the Phelps mine on James' fork. The mine was soon after abandoned, however, and was not operated in 1858 at the time of Swallow's Pacific railroad report; and after this, little or no mining seems to have been done in the county for the next 12 years or more. The Census for 1870 contains no reference to Greene county. In 1873, mines near Brookline were discovered, and, during 1875 and 1876, the Potter, Armstrong and Nixon mines were worked, and the first two have produced 152 and 40 tons of lead ore, respectively; after 1875 several tons of silicate of zinc were mined. In 1873, the Bull Winkle mine was discovered, but has produced only half a ton of silicate to date. In 1876, the Slogdill & Wilson furnace near Brookline was built, and was operated for several years afterward. In 1878, Prof. Williams, in describing the Ash Grove mines, refers to mining having been in progress for some time back at a few mines then examined. From the Pierson Creek mines, he states, 4000 tons of ore had been hauled to Ash Grove between 1875 and 1878.

As indicative of the amounts produced at the different camps, the following statement of shipments from different stations on the K. C., Ft. S. & M. R'y is included. It was kindly furnished by Mr. J. S. Ford, compt. of the road. The car-loads include lead and zinc, both as ore and metal:

SHIPMENTS OF LEAD AND ZINC ORES AND METALS
Over the K. C., Ft. S. & M. R. R.

Year.	Ash Grove.	Springfield	Turners.
1881.....	12 cars.	.....	.....
1882.....	10 "	.....	.....
1883.....	13 "	.....	.....
1884.....	1 "	.....	.....
1885.....	57 "	.....	.....
1886.....	6 "	.....	29 cars.
1887.....	3 "	2 cars.	23 "
1888.....	5 "	1 "	16 "
1889.....	23 "	1 "	6 "
1890.....	28 "	10 "	.....
1891.....	28 "	43 "	.....
1892.....	7 "	17 "	2 "
	193 "	74 "	76 "

The average weight of a car-load is given by the company as 17½ tons of 2000 pounds.

COUNTY PRODUCTIONS.

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In 1880, the Tenth Census credits the county with a production of 636 tons of lead ore and 43 tons of zinc ore. In 1886, the Everaole and Eaton mines on Pierson creek were discovered, and have produced 13 tons of blende. The Phelps mine was reopened about 1885, and was worked intermittently up to 1891, producing about 117 tons of lead ore and 552 tons of blende. The production of the Gumbo and Kodak mines of the Pierson creek group is estimated to have been 2000 tons of blende and 215 tons of galena up to 1891. A number of other mines were also worked between 1880 and 1890.

In 1885, Matthiessen & Hegeler purchased some blende from Springfield, and in the succeeding years obtained the following amounts:

1886	565 tons blende.
1887	530 " "
1888	290 " "

For the years 1889 to 1892 we have the following figures:

U. S. Census.	Tons lead ore.	Tons zinc ore.
1889.....	330= \$9,871.....	676= \$17,139
State Mine Inspector (years ending June 30).		
1889.....	70= \$2,862	628= \$12,268
1890.....	341= 14,946	553= 10,134
1891	200= 9,716	1,071= 20,710
1892.....	465= 18,479	898= 18,965
During 1893 the Pierson's Creek mines produced 550 tons of blende and 100 tons lead ore.		

Hickory County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	Tons	Values.	Tons.	Values.	Tons.	Values.	Tons.	Values.
1868 to 1869.....	250*	\$15,000	175	\$29,650	.....	.....	.....	.....
1870 to 1879	125*	6,250	88	10,384	.....	.....	.....	.....
1880 to 1893	100*	4,300	70	5,740	50*	\$600	16	\$1,600
Totals	475	25,550	333	45,774	50	600	16	1,600

According to Major R. H. Melton, the first work in Hickory county was done in 1868, when about 250 tons of lead were mined at localities described later. After this, about 125 tons more were taken out, probably in the early seventies. Since that time no work was done until about the year 1891, when operations were resumed at a few pits, and about 75 tons of ore were shipped. Zinc ore, occurring in this county, has been marketed to a slight extent. In 1887, Matthiessen and Hegeler obtained 36 tons from here, mostly carbonate.

Jasper County.

Period.	Lead.				Zinc.			
	Ores.		Metals.		Ores.		Metals.	
	Tons.	Values.	Tons.	Values	Tons.	Values.	Tons.	Values.
1850 to '59.....	1,000*	\$40,000	700	\$75,600	.....	.....	.....	.....
1860 " '69.....	2,300*	138,000	1,610	273,700	.....	.....	.....	.....
1870 " '79.....	104,000*	5,200,000	72,800	3,590,400	58,000*	\$696,000	23,200	\$2,784,000
1880 " '93.....	125,000*	5,375,000	87,500	7,175 000	793,000*	17,446,000	341,190	34,119,000
Totals.	232,300	10,753,000	162,610	16,114,700	851,000	18,142,000	364,390	36,903,000

As has already been stated, lead mining in Jasper county began about the year 1850. The first figures of production were given by Swallow, according to whom there had been produced, up to and including 1851, about 340 tons of lead ore, or something less than 100 tons per annum. This rate we apply to the whole decade. The ore came mainly from several mines on Center and Turkey creeks.

From this time on, until 1870, no figures are available. Mining was prosecuted on about the same scale in 1858 as in 1854, and it probably continued so up to 1860. During the war it was prosecuted spasmodically by Confederates and Federals. Records exist of the active resumption of work at Granby, in 1865, and of an increased production. Probably the same is true of Jasper county, though to a smaller degree. This fact is borne out by figures of production for 1870, when large discoveries were first made about Joplin. The Ninth Census places the value of Jasper county's lead ore product for the year at \$37,500. Applying the value of \$50 per ton, this is equivalent to 750 tons. As we have reason to think the Census figures somewhat low, a production of 1000 tons is probably nearer correct. Assuming the production of 1864 as 100 tons, and allowing an increase of 100 tons per year up to 1869, the total of these six years would be 2100 tons. Adding 200 tons for the years preceding 1864, we obtain 2300 for the decade 1850-59.

In 1871, the yields at Joplin increased rapidly, with new discoveries. According to Campbell's Gazetteer (p. 744), 3000 tons of lead were produced there in 1872. According to Lloyd and Bauman, the production of Jasper county mines during 1871 and 1872 was 6750 tons of lead ore; while for the year 1873, the production was about 10,250 tons. Schmidt estimates the total output of the Joplin district, during 1871 to 1873 inclusive, at 25,000 tons of galena = 17,500 tons of lead, valued at \$2,450,000. In 1874, the production was at the rate of 200 tons per week.

During 1875, according to Campbell's Gazetteer, 9217 tons of lead ore were smelted at Joplin, and Joplin smelters shipped to St. Louis 5470 tons of lead, and other pits 505 tons. The total production of Jasper and Newton counties for that year is given as 8475 tons of lead, of which Jasper county is said to have produced four-fifths.

From Prof. Chas. P. Williams' report [238] we obtain the following information:

In 1874, Davis and Murphy furnace at Joplin received 3392 tons ore.

In 1875, the Granby furnace received from Joplin and Oronogo, 70 tons of ore per week=3,600 tons.

In 1875, Webb diggings yielded 25 tons of ore per week=1300 tons.

In 1875, the Lone Elm company received up to August 1st, 3200 tons.

In 1875, Picher and Brothers received about 50 tons per week=2600 tons.

In 1875, Joplin Mining and Smelting company received about 54 tons of ore per week=2800 tons.

Total, excluding Davis & Murphy furnace, 3500 tons ore.

For the year 1875, Prof. Williams credits Jasper county with the production of 4000 tons of zinc ore. Of this, 1491 tons were shipped to Matthiessen & Hegeler.

From 1876 to 1879 there are no reliable data, and we have to rely almost entirely upon estimates. As a check, we quote the following table, given by Pulsifer [177], of the total production of the Southwestern district:

PRODUCTIONS OF LEAD.

<i>Year.</i>	<i>Tons Lead.</i>	<i>Year.</i>	<i>Tons Lead.</i>
1873	12,280	1880.....	15,780
1874	13,830	1881.....	15,500
1875	13,525	1882	11,670
1876	14,634	1883	7,645
1877	17,765	1884	2,665
1878	13,650	1885	6,070
1879.....	13,928	1886.....	6,482

The 10th Census gives the output for the year 1880, of the Southwestern district, including Christian, Dade, Greene, Jasper, Newton and Wright counties, as only 13,237 tons of lead ore, of which Jasper county produced 10,873 tons. The average of this and Pulsifer's figures for the same year is about 18,000 tons, and of this we assume that 14,000 came from Jasper county. Comparing this with the figures given in 1875, we see the increase was not very great. Considering these figures, and bearing in mind the increase of 1877 indicated by Pulsifer's table, a production of 60,000 tons of ore for the four years, 1876 to 1879 inclusive, is probably quite close. Adding for 1870 a production of 1000 tons of ore; for 1871-73 Lloyd & Bauman's figures of 17,000 tons; for 1874, 12,500 tons, and for 1875, Williams 13,500, we obtain a total for the decade of 104,000 tons lead ore.

Figures of zinc production up to 1880 are very scarce. During the years given, the following amounts were shipped to Matthiessen & Hegeler. They exclude the Granby productions, but include other points of southwestern Missouri and Kansas; until 1877, however, when Galena (Kansas) mines began to produce, they represent essentially shipments from Jasper county.

TABLE OF SHIPMENTS TO MATTHIESSEN AND HEGELER.

<i>Tons blende.</i>	<i>Tons blende</i>
1873	482
1874	2,542
1875	1,491
1876.....	*5,461
1877	4,981
1878	4,796
1879	10,181
1880.....	13,770
1881	23,433
1882	18,355
1883.....	16,641
1884.....	19,790
1885.....	16,011
1886.....	17,981
1887.....	22,305
1888.....	20,268
1889.....	21,566
1890.....	†19,479

*And 24 tons carbonate.

†And 65 tons carbonate from Carthage.

The Tenth Census credits Jasper county with 21,304 tons of zinc ore in 1880. Assuming a constant increase from the 4000 of 1875, the total production of the intervening four years would be about 50,000 tons. Allowing 8000 for the years 1873, '74 and '75, we get a total of 58,000 for the decade.

LEAD AND ZINC DEPOSITS OF MISSOURI.

For the years 1881 to 1888 inclusive, Mesarra, Mattheussen and Hegeler have kindly furnished the following figures, based upon observations and notes collected by their buyer, Mr. C. Guengrich. These practically represent the productions of Jasper county:

LEAD ORE PRODUCTIONS OF SOUTHWESTERN MISSOURI MINES.

Exclusive of mines at Granby and Galena, Kansas.

Years.	Tons blende.	Years.	Tons blende.
1881.....	34,534	1885.....	48,735
1882.....	33,735	1887.....	57,145
1883.....	34,268	1888.....	61,392
1884.....	43,750	Total.....	354,318
1885.....	40,759		

Mr. John N. Wilson and others [242] give the production of Jasper county for the year ending March 1st, 1887 as:

Zinc ore50,337 tons, at \$19.13 per ton = \$965,551.

Lead ore..... 6,705 tons, at \$49.40 per ton = \$331,627.

From the Mine Inspector's report, for the year ending October 15, 1888, the value of Jasper county's lead and zinc product is placed at \$2,421,100.

For the year 1889, the U. S. Census gives the following:

Zinc ore72,026 tons, at \$22.62 per ton = \$1,629,537.

Lead ore..... .5,810 tons, at \$42.32 per ton = \$245,856.

The following are given in the State Mine Inspector's reports for the years ending June 30th:

PRODUCTIONS OF JASPER COUNTY MINES.

Years.	Zinc ore.		Lead ore.		Years.	Zinc ore.		Lead ore.	
	Tons.	Values.	Tons.	Values.		Tons	Values.	Tons.	Values.
1889 ...	59,162	\$1,403,418	5,330	\$247,095	1892 ...	106,010	\$2,416,333	11,501	\$530,094
1890 ..	74,141	1,827,966	7,160	324,636	1893....	82,587	1,833,447	10,241	434,968
1891....	95,376	2,220,542	7,994	391,182					

As a further contribution, we add the following tables of shipments, kindly furnished by Mr. John A. Sargent, General Freight Agent of the K. C., F. S. & M. railway, and by Mr. C. G. Warner, General Auditor of the Missouri Pacific railway:

SHIPMENTS FROM JOPLIN (K. C., F. S. & M. RAILWAY).

Years.	Lead ore	Zinc	Zinc ore.	Total.	Years.	Lead ore	Zinc.	Zinc ore.	Total.
	Tons.	Tons.	Tons.	Tons.		Tons.	Tons.	Tons.	Tons.
1879.....	7,490	402	8,365	.....	1886.....	.....	.....	.....	13,457
1880.....	3,272	52	6,930	.....	1887.....	.....	.....	.....	10,657
1881.....	1,102	.....	4,795	.....	1888.....	.....	.....	.....	5,068
1882.....	1,037	1,015	1,977	.....	1889.*.....	.....	.....	.....	1,697
1883.....	.....	.....	.....	3,675	1890.....	.....	.....	.....	10,508
1884.....	.....	.....	.....	7,350	1891.....	.....	.....	.....	12,355
1885.....	.....	.....	.....	10,150	1892.....	.....	.....	.....	17,535

Years.	Total metal and ores.	Years.	Total metal and ores.
<i>From Webb City—</i>	<i>Tons.</i>	<i>From Webb City—</i>	<i>Tons.</i>
1882		1891	7,315
1883	9,135	1892	9,310
1884	11,707	<i>From Belleville—</i>	
1885	9,992	1888	10,150
1886	9,712	1889*	3,745
1887	6,457	1890	9,135
1888	6,912	1891	4,900
1889	3,377	1892	3,132
1890	8,785		

*First six months.

SHIPMENTS BY MO. PAC. R'Y.

Year.	Joplin.		Carthage		Webb City.	
	<i>Lead.</i>	<i>Spelter.</i>				
1886	400 tons.	250 tons.				
1887	200 "	200 "				
1888	550 "	400 "				
1889	600 "	490 "				
1890	500 "	250 "				
			<i>Lead ore.</i>	<i>Zinc ore.</i>	<i>Lead ore.</i>	<i>Zinc ore.</i>
1891	800 "	360 "		2,924	1,248	38,900
	4,060 lead ore.	4,090 zinc ore.				
1892	600 lead.	400 zinc.	15	3,747	1,844	40,220
	1,500 lead ore.	3,050 zinc ore.				

With these data we obtain the total productions for 1880 to 1893, as follows:

Year.	Tons lead ore.	Year.	Tons zinc ore.
1880	14,000 (Census).	1880	21,300 (Census).
1881 to 1885	50,000 (estimate based on Pulsifer)	1881 to 1888	354,318 (M. & H.)
1886	6,700 (Wilson).	1889 to 1893	417,280 (Mine I.)
1887 to 1888	12,000 (estimate).		
1889 to 1893	42,226 (Mine I.).		
Total	124,926	Total	792,898

LEAD AND ZINC DEPOSITS OF MISSOURI.

Jefferson County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1800 to 1819	333	\$13,320	200*	\$18,000	.....	.....	.....	.....
1820 to 1829	2,420	96,800	1,500*	150,000	.....	.....	.....	.....
1830 to 1849	7,200*	288,000	4,680	421,200	.....	.....	.....	.....
1850 to 1859	4,500*	180,000	3,150	340,200	.....	.....	.....	.....
1860 to 1869	2,000*	120,000	1,400	238,000	.....	.....	.....	.....
1870 to 1879	4,000*	200,000	2,800	330,400	3,000*	\$30,000	1,000	\$120,000
1880 to 1892†	6,210	267,030	4,347*	356,454	31,561*	378,732	10,520	1,052,000
Totals	26,653	1,165,150	18,077	1,854,254	34,561	408,732	11,520	1,172,000

† The workings of the Valle mine are situated both in Jefferson and St. Francois counties, but most of the work has been done in St. Francois county, especially in the earlier years. It is impossible to make an exact separation of the production by counties. We have, hence, assumed an arbitrary one, and have credited to St. Francois county all of the output preceding the year 1880, and to Jefferson county all succeeding that year.

We have no record of mining in Jefferson county before the year 1800. Between that date, and 1819, work had been done only at Gray's and McKane's mines on Dry creek. These were not referred to by Anstin in 1804, and were probably not opened then; neither of them were being worked in 1819. They were considered unimportant producers, and our allowance of 200 tons for their production up to 1820 is probably liberal.

Between 1820 and 1829, mining became quite active in the county. In 1824, the Sandy mines were discovered and the Vaile mines also, but, as the production of the latter up to 1880 is assigned to St. Francois county, it is left out of consideration here. About the same time, diggings on Platin creek, near what was later McCormick's mine, were worked. In 1826, the Sandy mines are reported to have yielded 442 tons of ore, according to Mr. Cobb, and in 1832 their rate of production was 333 tons. In 1827, the Nashville mines were opened, but are credited with an output of only 50 tons to 1856. It is probable Gray's mine and McKane's were worked during this decade. From these facts we estimate the average annual production for the ten years at 150 tons of lead.

For the years 1830 to '49 we have the following notes: The Sandy mines are credited by Cobb with an average annual production of 167 tons of ore for the whole period. In 1840, Howe's diggings were discovered, but, according to Shumard, produced only 75 tons of ore up to 1856. In 1842, the Frissel mines were also discovered, but produced only 50 tons up to 1856. In 1843, the Mammoth mines were opened, and by 1852, according to Litton, had yielded 2500 tons of ore, and of this only 11 were mined in the years 1851 and 1852.

In 1834, the Taplit and Perry (probably the same as the Tarpley) was working; no figures of early output are obtainable, but Litton gives for the Tarpley mine a production of 365 tons of ore for the years 1845 to 1849, inclusive. In 1836, Lee's diggings were operating, and Gray's mines were also worked intermittently during these 20 years. Our allowance for the period is, therefore, obtained as follows:

	<i>Tons ore.</i>		<i>Tons ore.</i>
Sandy mines	3,300	Tarpley	1,000
How's & Frissel	100	Other mines	400
Mammoth	2,400	Total	7,200

During the years 1850 to 1859, mining continued at about the same rate. In 1852, the Mammoth mine ceased work. In 1855, the McCormick diggings produced 7 tons, and, in the same year, the Poston & Tyler 45 tons. Between 1851 and 1853, the Tarpley mine output was 450 tons of ore, according to Shumard and Litton. In 1856, the Daly mine produced 30 tons of ore, the Robinson 25 tons, and the Gopher and Herculanenm about 60 tons, and up to the same year the Nashville mine had produced about 50 tons, and the How mine about 75 tons. The Sandy mine continued work up to this year, when it was purchased by other parties and preparations for large operations were made. Gray's mines were also operated, and in 1859, the Darby mine yielded 125 tons of ore. Our allowance for the decade is, therefore, made up as follows:

	<i>Tons ore.</i>		<i>Tons ore.</i>
Tarpley mine.....	800	Nashville, How's, Gray and others	900
Mammoth & McCormick.....	100	Sandy mine.....	1,000
Poston, Tyler & Daly.....	600	Total.....	4,500
Gopher, Herculanenm and Darby	1,100		

For the decade of 1860 to 1869, we have very few figures upon which to estimate the production excepting for the Darby mine. Of this we have the following, kindly furnished by Mr. George McFarland, of Frumet:

PRODUCTIONS OF THE DARBY MINES.

	<i>Tons ore</i>		<i>Tons ore.</i>
1859	125	1870.....	52
1860	150	1871.....	45
1861	100	1872.....	33
1862	31	1873	21
1863	25	1875	17
1864	43	1880	18
1865-66.....	47	1888	12
1867	60	1889	20
1868	48	1890	21
1869.....	75	Total.....	943

The years omitted in the above table are those during which the mine was operated by Wm. Einstein & Co. and later by A. Mandel & Co. The output for these years is estimated at 20 tons annually.

Beyond this we have nothing, and are forced to rely entirely on an estimate. Considering the production of the Darby mines and the unsettled times as compared with the preceding decade, we think an allowance of 2000 tons ample.

In arriving at the total for the years 1870 to 1879, we obtain, from the preceding table, the output of the Darby mines, aggregating about 269 tons of ore. In 1874, the Frumet mines, according to Campbell's Gazetteer, were producing about 4 tons of lead per day and large quantities of zinc ore; one Flintshire and one cupola furnace were in operation there in 1875. In 1872 Broadhead states that 1713 tons of zinc ore were shipped to St. Louis from Jefferson county, but part of this was, without doubt, from the Valle mine. Doubtless, however, this county shared with others the activity in mining, brought about by the high prices of the first years. Therefore, guided by this consideration, and by the figures of production for the preceding and succeeding decades, we think an allowance of 4000 tons of lead ore and 3000 tons zinc ore entirely moderate.

For the years 1880 to '93 we have, first, the figures of the Tenth Census, which credits the county with a production of 56 tons of lead ore, and no zinc ore in 1880. The average production of the Darby mine was 20 tons of lead ore per year. The Valle mines were large producers during this period, and their output, given in the table in chapter XV of this report, is included here. The Eleventh Census credits the county with no output for the year 1889, probably including the Valle

LEAD AND ZINC DEPOSITS OF MISSOURI.

mine in St. Francois county. For the five years, 1889 to '93, the State Mine Inspector gives the following figures, which include the output of the Valle mines (years ending June 30):

PRODUCTIONS OF JEFFERSON COUNTY 1889 TO 1893.

	<i>Tons Lead ore.</i>		<i>Tons Zinc ore.</i>	
1889	309	= \$16,447	2,055	= \$23,901
1890	277	9,972	2,614	35,070
1891	497	21,371	2,116	31,865
1892	412	18,980	2,075	26,041
1893	1,024	34,396	1,562	14,058

Our allowance for the fourteen years is therefore obtained as follows:

	<i>Tons Lead ore.</i>		<i>Tons Zinc ore.</i>	
Valle mine, 1880 to '90.....	2,600		24,107	
" " 1891 to '93	1,347		5,762	
Darby "	200			
Other diggings	200		1,693	
Totals.....	4,374		31,562	

Lawrence County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
Before 1886..	100*?	\$5,000	70	\$8,260	.....	.....	.....	.....
1886 to 1893..	25,767*	1,127,946	18,037	1,479,034	83,711*†	\$1,240,962	30,601	\$3,060,100
Totals.....	25,867	1,132,946	18,107	1,487,294	83,711	1,240,962	30,601	3,060,100

† Two-thirds silicate and one-third blende.

Swallow, in 1858, refers to mines or prospecting pits in Lawrence county, namely: the Williams, in the extreme northeast, which was not being worked, and the Richey, in the extreme southeast, which was then operated. A discovery of lead ores was also made near Mt. Vernon about 1869; it was worked in a small way for a short time in 1873.

The county did not take rank as an ore producer, however, until 1886, the first ore being turned out at Aurora in April of that year. For the year 1886, Mr. Wilson states the production of the county to be as follows:

For 1886 (year ending March 1, 1887), 1768 tons lead ore=\$69,500; 240 tons zinc ore=\$2,022.

In 1888, the State Mine Inspector's report gives the production of the county, for 5½ months, as 748 tons lead ore, at \$25 to \$30 per ton, and 1487 tons zinc ore, the silicate selling at from \$8 to \$11 per ton, and the blende at from \$18 to \$25.

For the next 5 years we have the following table:

U. S. Census:	<i>Tons lead ore.</i>		<i>Tons zinc ore.</i>	
1889	3,005	= \$118,161	9,463	= \$158,665
Mine Inspector (years ending June 30).				
1889	1,281	= 54,433	13,027	= 177,518
1890	2,873	= 126,793	12,877	= 197,711
1891	4,462	= 231,042	15,353	= 234,655
1892	5,721	= 264,136	13,861	= 224,401
1893	4,462	= 231,042	15,353	= 234,655
	18,797	= 907,446	70,471	= 1,068,940

The figure given for the production of lead ore in 1889 by the Mine Inspector seems inordinately low, and we are inclined to adopt that of the Census in its place. Estimating the productions of the missing years by interpolation, we obtain the total given in the table.

Maries County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1870 to 1879	100*	\$5,000	70	\$8,260	.....	.....	.....	.....
1880 to 1893 .....	.....	.....	.....	.....	10*	\$220	4	\$400
Totals	100	5,000	70	8,260	10	220	4	400

But little mining has been done here during past years. In 1874, the Williams mine was opened, and it is estimated that about \$2000 worth of lead ore was taken out. This would be equivalent to about 50 tons. In addition, large amounts are said to have been taken from other pits in the neighborhood. The Future Great Mining company, near Vichy, began operations about 1890, and a number of tons of ore, mostly blende, were mined within the year. Probably 10 tons would cover the total zinc ore production. For the total county output, we allow 100 tons of lead ore.

Madison County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values</i>	<i>Tons.</i>	<i>Values</i>
1720 to 1799.	16,000	\$640,000	8,000*	\$800,000	.....	.....	.....	.....
1800 " 1819	8,333	333,320	5,000*	450,000	.....	.....	.....	.....
1820 " 1829	4,840	193,600	3,000*	300,000	.....	.....	.....	.....
1830 " 1849	20,746	829,840	13,485*	1,213,650	.....	.....	.....	.....
1850 " 1859	855	34,200	600*	64,800	.....	.....	.....	.....
1860 " 1869	13,555	813,300	9,500*	1,615,000	.....	.....	.....	.....
1870 " 1879	28,555	1,427,750	20,000*	2,360,000	.....	.....	.....	.....
1880 " 1893	54,456	2,341,608	38,119*	3,125,758	.....	.....	.....	.....
Totals	147,340	6,613,618	97,704	9,929,208	.....	.....	.....	.....

The productions of Madison county are synonymous with those of Mine La Motte, as this is, so far, the only lead mine in the county. Mining began there about 1720. Estimates of the output of early years, and detailed productions of later years, are given in the description of the mine. From there the tables have been prepared. They need not be repeated here.

Miller County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
Before 1870	100*?	\$6,000	70	\$11,900	.....	.....	.....	.....
1870 to 1879	2,000*	100,000	1,410	166,380	.....	.....	.....	.....
1880 to 1893	100*	4,300	70	5,740	.....	.....	.....	.....
Totals	2,200	110,300	1,550	184,020	.....	.....	.....	.....

In 1854, the Copps' mine is stated to have been worked; but, in 1856, Meek describes only a few prospects in the county. In 1870, the Ninth Census places the value of Miller county products at \$6115, which represents about 150 tons of ore. Soon after this, the most active period of mining in the county began. According to the report of the State Geological Survey, there were 13 diggings in 1874 and 2 furnaces; of these, six had produced over 1000 tons of ore to date, and almost all of this since 1870. The other mines had produced additional but small amounts. In 1876 the 2 furnaces still existed in the county. The Census of 1880 and 1889 contain no mention of Miller county, neither do the Mine Inspector's reports until the last 2 years, when the production for 1891 is given as 14 tons lead ore, valued at \$725, and that for 1892 as 25 tons lead ore, valued at \$1155.

Moniteau County,

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1840 to 1849	1,200*	\$48,000	780	\$70,200	.....	.....	.....	.....
1850 to 1859	500*	20,000	350	37,800	.....	.....	.....	.....
1860 to 1869	150*	9,000	105	17,850	.....	.....	.....	.....
1870 to 1879	500*	25,000	350	41,300	.....	.....	.....	.....
1880 to 1893	150*	6,450	105	8,610	500*	\$11,000	215	\$21,500
Totals	2,500	108,450	1,690	175,760	500	11,000	215	21,500

In 1841, the High Point mine was discovered, and was worked until 1845, up to which time it produced 1000 tons of ore. In 1854 it was reopened, and was worked until 1857. About the same time, according to Prof. Meek's report, ore was being dug at 10 localities. At one mine operated by Messrs. English, Sartin & Wells, as much as 5 tons of ore had been taken out in one day; this mine had also been profitably worked before 1850. From this time on we have no records of production in the county up to 1870, but operations probably practically ceased during the period of the war.

In 1870, the Census values the ore product of the county at \$1100, which is equivalent to about 30 tons. In 1874, the State Geological Survey report describes six diggings and one furnace in the county, four of which produced during 1873 and 1874, 116 tons of ore. The furnace was apparently not operating in 1876.

The Census of 1880 credits the county with only 3 tons of lead ore, while the Census of 1889 contains no mention of it. For 1890, the Mine Inspector gives 12 tons of lead ore, valued at \$480, and for 1891, 3 tons of lead ore, valued at \$135, and 7 tons of zinc ore at \$161. No figures are given for 1892 or 1893.

The following are shipments from Mo. Pacific stations:

Moniteau.		Tipton.	
1887—Lead ore		1887—Zinc ore.....	120 tons.
1888— “		1888— “	280 tons.
1889— “	7 tons.	1889— “	20 tons.
1892— “	12 “	1892	

Some of this zinc ore probably came from Morgan county, but in absence of definite information we credit it to Moniteau.

Morgan County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1830 to 1849.....	100*	\$4,000	65	\$5,850	.....	.....	....	.....
1850 to 1859.....	50*	2,000	35	3,780	.....	.....	.....	.....
1860 to 1869	200*	12,000	140	23,000	.....	.....	.....	.....
1870 to 1879	3,000*	150,000	2,100	247,800	.....	.....	.....	.....
1880 to 1893	200*	8 600	140	11,480	60*	1,320	26	2,600
Totals	3,550	176,600	2,480	292,710	60	1,320	26	2,600

Mining in Morgan county began near the year 1837, when about half a ton of lead ore was taken out by some German miners. About 1840, shafts were sunk on Wyan, Trig and Bryan's lands; near the same time a Mr. Roas obtained some 1200 pounds of lead ore near Versailles. In 1843, mines near Gravois village were operated, and one shaft, sunk by Mr. T. V. Jones, produced nearly three tons of lead in that year. Up to 1856, according to Prof. Meek, these Gravois mines had yielded about 25 tons of ore. Mines worked by Tole & Skeeton near Indian creek, according to Prof. Meek, had produced over 20 tons. In 1867, the Bond furnace was built, and some ore must have been produced, though the Census of 1870 does not credit the county with any production. Soon after this, however, mining became active.

In 1874, according to the report of the State Geological Survey, there were 56 openings worked and 7 furnaces. During the last six months of this year, 500 tons of galena were produced. Of 34 of these openings, the individual productions are given, and aggregate 1867 tons. Most of this is the yield of 1873 and 1874, but some of the items are of total productions to date. In 1876 the seven furnaces still existed in the county, according to Prof. Williams.

LEAD AND ZINC DEPOSITS OF MISSOURI.

The Census of 1880 credits the county with 4 mines, producing 64 tons of lead ore. That of 1889 returns no lead ore, but 15½ tons of zinc ore, valued at \$480. The state mine inspector makes the same allowance for the year 1889; for 1890, he gives 4 tons of lead ore, valued at \$90, and no zinc ore; for 1891, 40 tons zinc ore, valued at \$920, and no lead ore.

In addition to the above facts, we have for guidance the following table, kindly furnished us by Mr. R. B. Richardson, of Versailles. The information was obtained chiefly from owners and former managers of smelters, and their statements are believed to be substantially correct, and certainly not exaggerated. One or two other furnaces were in operation in the county in the late sixties and the early seventies which are not included.

PRODUCTION OF LEAD FURNACES IN MORGAN COUNTY.

<i>Tons Lead.</i>		<i>Tons Lead.</i>	
Clark's Air, otherwise known as the Star furnace.	850	Otterville furnace	20
Bond's furnace.	200	O'Bryans' Scotch hearth furnace	150
Wyan Spring furnace.....	500	Gabriel furnace.....	30
Handlin (included in Clark's Star above)		Brushy furnace.....	15
Buffalo furnace.....	225	The Cole Camp (Benton county) furnace, operated by Morgan county owners, smelted	50
Jackson county (Gum spring) furnace	105	Total	2,145

According to Mr. George P. Clark, of Versailles, who was the owner of a smelter in the county which was longer operated than any other, the lead given in the table was smelted between the years 1869 and 1877, the principal smelters being Bond's, Wyan spring, Rocky ford, Gum springs and Buffalo mines. Mr. Clark's smelter was at Rocky ford, and ran at intervals up to 1880. According to Mr. Richardson, 10 or 12 car-loads of galena have been shipped to other points since the smelters have shut down.

The Mo. Pac. R'y books show the following shipments of zinc ore from Versailles:

1890	1 ton.
1891	10 "

Newton County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1850 to 1859.	24,285	\$971,400	17,000*	\$1,836,000	.....	.....	.....	.....
1860 " 1869.	10,000	600,000	7,000*	1,190,000	.....	.....	.....	.....
1870 " 1879.	20,000*	1,000,000	14,000	1,652,000	50,000*	\$500,000	16,667	\$2,000,000
1880 " 1893.	23,000*	989,000	16,100	1,320,200	133,000*	1,596,000	44,333	4,433,300
Totals....	77,285	3,560,400	54,100	5,998,200	183,000	2,096,000	61,000	6,433,300

Lead mining in this county began about 1850. Up to 1854, Swallow estimates the total production at about 520 tons of ore. After 1856, Schmidt states that it rose to over 4000 tons of ore per year [32, p 493]. In 1888, however, Swallow places the whole output of the Granby mines at about 4000 tons of lead ore [219, p 92], and, further, states that between February 1st and September 1st,

Blow & Kennett's furnace smelted 805 tons of lead. According to Campbell's Gazetteer (p. 400), the Granby mines yielded up to 1860, 17,707 tons of lead. From this data we allow a production of 17,000 tons of lead for the years 1850 to '59.

During the war, the Granby mines were worked at intervals by both Confederates and Federals. Immediately after the cessation of hostilities, work was resumed by H. T. Blow. In 1870, the Census places the value of Newton county's lead production at \$72,500. This, at \$50 per ton, would be equivalent to 1450 tons of ore. We have seen that the Census figures are too low in other counties, and we think here the same is the case, and that 2000 tons is probably nearer the truth. Assuming the production in 1864 to be 200 tons of lead ore, and the increase to be regular up to 1870, the total for the five years ending with 1869 would be about 6000 tons. This is in harmony with the statement given by Campbell, that between the years 1860 and 1873 the Granby mines yielded 9838 tons of lead, and large amounts were not accounted for.

From 1870 to 1893, Mr. John P. Neville, president of the Granby Mining & Smelting company, writes that the Granby mines produced on an average 1250 tons of lead ore and 6230 tons of zinc ore since 1868. Broadhead gives a shipment of 2400 tons of zinc ore from Granby in 1872 [32, p. 698]. In 1872, Campbell (p. 741) states that the production of Granby was 1650 tons of lead. According to Lloyd and Bauman, the Granby company shipped in 1873, 2293 tons of pig lead, equivalent to about 3400 tons of ore; of this about one-half came from the Granby mines. In 1872, according to the same authority, St. Louis received 2419 tons of zinc ore from Granby. Schmidt (p. 501) estimates the total production of Granby to the end of 1873 at 40,000 tons of galena. In 1874, the Granby district was producing about 35 tons of galena weekly. For 1875, Williams (p. 175) allows Newton county a production of 8500 tons of zinc ore. From this time to 1879, the only check we have are Pulsifer's tables of productions for the whole southwest, given under Jasper county, and Mr. Neville's general statements, which we think are too low. Considering these facts, and allowing for productions of mines outside of Granby, we think an allowance of 2000 tons of lead ore per year entirely moderate. Zinc ore we allow an average production of 7000 tons for 7 years.

In 1880, the Census credits Newton county with a production of 1289 tons of lead ore; this, increased proportionally as was Jasper county, is equivalent to about 1700 tons. The Census figures for zinc ore for that year are 9550 tons. In 1831 to 1882, Matthiessen and Hegeier purchased 4000 tons of silicate from Granby.

For 1836, Wilson's figures are as follows:

Lead ore 1,761 tons=\$80,873 Zinc ore 10,912 tons=\$155,532

For 1888, the Mine Inspector gives the production for the year ending October 15, as follows:

Lead ore 1,861 tons Zinc ore 11,250 tons

The latter figure is possibly too high.

For 1889, the Census figures are as follows:

Lead ore 170 tons=\$7,074 Zinc ore 8,307 tons=\$191,487

For the years 1889 to 1893, the Mine Inspector's are given in the following tables for years ending June 30:

	Lead ores.		Zinc ores.	
	<i>Tons.</i>	<i>Value.</i>	<i>Tons.</i>	<i>Value.</i>
1889.....	1,863	\$76,148	6,990	\$142,642
1890.....	1,756	87,700	8,285	166,206
1891.....	1,605	70,875	7,901	139,829
1892.....	1,250	55,059	8,342	172,529
1893.....	1,457	58,391	8,043	107,350

LEAD AND ZINC DEPOSITS OF MISSOURI.

Our summary for 1880 to 1893 is hence derived as follows:

Year.	Tons lead ore.	Year.	Tons zinc ore.
1880	1,700 (Census).	1880	10,000 (Census).
1881 to 1885	8,000 (estimate).	1881 to 1885	50,000 (estimate)
1886	1,761 (Wilson).	1886	10,912 (Wilson).
1887	1,800 (estimate).	1887.....	11,000 (estimate)
1888	1,861 (Mine I.).	1888.....	11,250 (Mine I.)
1889 to 1893	7,892 (Mine I.).	1889 to 1893	39,561
Total.....	22,954	Total....	132,723

Perry County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	Tons.	Values.	Tons.	Values	Tons.	Values.	Tons.	Values.
1820 to 1829	25*	\$1,000	16	\$1,600	.....	.....	.....	.....
1830 " 1849.....	50*	2,000	33	2,880	.....	.....	.....	.....
1850 " 1859.....	100*	4,000	70	7,560	.....	.....	.....	.....
1860 " 1869.....	150*	9,000	105	17,850	.....	.....	.....	.....
1870 " 1879.....	150*	7,500	105	12,390	.....	.....	.....	.....
1880 " 1893.....	100*	4,300	70	5,740	.....	.....	.....	.....
Totals	575	27,800	399	48,110	.....	.....	.....	.....

In 1827, the Wilkinson diggings were opened, and were worked up to 1828, producing about 20 tons of ore. They were then abandoned until 1833, when they were reworked a little, according to Shumard, and considerable ore was obtained. They were reworked with profit in 1856. A few other operations were conducted at other points in these early years. During the years 1868 to 1872, according to information kindly furnished by Mr C. A. Weber, of Perryville, mines were worked near that town, and produced 300 tons of lead ore. Work was then abandoned until 1888. During that year and 1889, operations were resumed, and about 75 tons of ore were mined. According to the State Mine Inspector's report, they produced in 1891, 15 tons of lead ore, valued at \$675; in 1892, six tons of lead ore, valued at \$163

Saline County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1870 to 1879.	100*	\$5,000	70	\$8,260	.....	.....	.....	.....
1880 to 1893.	200*	8,600	140	11,480	.....	.....	.....	.....
Totals.....	300	13,600	210	19,470	.....	.....	.....	.....

Some mining has been done in this county during the past 20 years. Very few facts of productions are, however, available. The Marmaduke diggings began about 1874, and in that year about 10 tons were produced. Later, the Collins mine was operated, and some \$20,000 worth of lead is reported to have been taken out. We think an allowance of 300 tons of ore a liberal one for this county.

St. Francois County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1740 to 1799....	1,000*	\$40,000	500	\$50,000	.....	.....	.....	.....
1800 to 1819....	5,000	200,000	3,000*	270,000	.....	.....	.....	.....
1820 to 1829....	7,263	290,520	4,500*	450,000	.....	.....	.....	.....
1830 to 1849....	27,692	1,107,680	18,000*	1,620,000	.....	.....	.....	.....
1850 to 1859....	11,428	457,120	8,000*	864,000	.....	.....	.....	.....
1860 to 1869....	7,143	428,580	5,000*	850,000	200*	\$2,000	67	\$8,000
1870 to 1879....	34,285	1,714,250	24,000*	2,832,000	26,512*	265,120	8,837	883,700
1880 to 1893†... 260,000	11,118,000	182,000*	15,924,000	.....	.....	.....	.....	.....
Totals	353,811	14,817,150	245,000	22,860,000	26,712	267,120	8,904	891,700

† The figures for 1890 to 1893 do not include the productions of the Valle mine, those of the preceding periods do; for the period of 1880 to 1893, the productions of the Valle mine are included in Jefferson county.

During the eighteenth century, the first notice of mining in St. Francois county is at Mine a Gebore, where work was feebly prosecuted between the years 1742 and 1762; and this seems to have been about the only mine worked up to near the end of that period. About 1795 Mine a Layne was discovered, but did not produce much, while in 1799 Mine a Manteo, on Big river, was opened, and considerable ore was taken out. The Mine a LaPlate was worked about the same time, and yielded a few tons of ore. From all the data available, we conclude that a production of 1000 tons of ore for this century is a liberal, though not excessive allowance.

Between the years 1800 and 1819 we have a little more information. In 1801 the Bogy, or Mine a Joe, was discovered, and a large amount of ore was taken out during the first year. In 1806 the Hazel Run mines were opened, including Gray and Doggett's, and Schoolcraft records that 500 tons of lead were taken out in the first year. These mines were worked up to 1823; from 1817 to 1819 they produced 455 tons of lead, or 152 tons a year. In 1811, Brackenridge states that Bryan's mines produced 300 tons of lead. We have therefore taken 150 tons of lead as the average annual production during these 20 years, giving a total of 3,000 tons.

Between the years 1820 and 1829, mining increased in the county. In 1823 the Flat river mines produced 200 tons of lead, according to the Land Office report, while the total production of Washington and St. Francois counties is placed at 2500 tons of lead. The Mines a Joe and Pratt mines were probably worked during this period. In 1823, work at the Bryan mine ceased. In 1824, the Valle mine was discovered, and produced between 1824 and 1830, according to Dr. Litton, 2615 tons of lead. In 1825 the Bisch mine was opened, and produced at the rate of about 100 tons of lead per year. The Perry mines were discovered a little later. We thus estimate the production of the county as follows:

Valle mines, 1824 to 1829, about	2,000 tons of lead.
Bisch & Perry, " "	1,000 " "
Flat River mines, " "	1,200 " "
Other mines, " "	300 " "
Total	4,500 " "

For the years 1830 to 1849, Dr. Litton, in his report of 1854, gives many valuable figures of the productions of the mines of this county, including the annual productions of the Valle, Perry & Bisch mines, and the outputs of their furnaces. From these figures we compiled the following table:

Productions of the Valle mine, 1830 to 1850. 5,839 tons of lead.
 " " Perry " " 6,923 tons ore=4,600 tons of lead.

The total output of the Bisch, Valle and Perry furnaces from 1839 to 1849, inclusive, he places at 7837 tons of lead. To this we add the following estimates based upon his figures:

Productions Bisch mine, 1830 to 1838, inclusive.....	900 tons of lead.
" Valle " " "	4,260 " "
" Perry " " "	4,000 " "
" other mines, 1830 to 1849, "	1,003 " "
Output of furnaces as above, 1839 to 1849, inclusive.....	7,837 " "
Total for the 20 years.....	18,000

During the decade from 1850 to 1859, we have the following table, derived from Litton:

Productions Valle mine, 1850 to '54.	1,445 tons of lead.
" Perry " "	2,132 " "
" Bisch " "	1,000 " "
Total.....	4,577

For the years 1855 to 1859, Mr. Gage [32] gives the output of the Valle mine as 1870 tons of lead. According to notes furnished us by Mr. Felix Rozler, and given in the mine descriptions, the lead made into pigs by Bisch and Rozler, at the Perry mine, during the years 1855 to 1859 inclusive, amounted to 497 tons.

The sum of these totals amounts to 6944 tons of lead. In addition, some little work was done at the Pratt and La Grave mines, at Bonne Terre. We, hence, consider an allowance of 8000 tons of lead a just one for this period.

For the productions between the years 1860 and '69, we have the valuable table of the lead manufactured at the Valle mine, included in the mine descriptions. From this table we find that the production between the years 1862 and 1869 was 2319 tons of lead. Referring to the production of 1855 to '59, and to that for 1862, we estimate the output of the Valle mines, for the years 1860 and 1861, at 600 tons.

In 1864, the St. Joseph Lead company was organized, and produced, in 1865, 240 tons of lead. The productions for the years 1869 to 1893, are given in a table in chapter XV of this report. From this table we estimate the production between the years 1865 and 1868 inclusive, as 1000 tons of lead. That for 1869 is given as 261 tons, making a total for this decade, from Bonne Terre, of 1261 tons.

Summarizing, our allowance for the whole county for this decade is obtained as follows:

Valle mines	2900 tons lead	Other mines of the county	800 tons lead
St. Joseph Lead Co.....	1300 "	Total.	5000 "

Concerning the production of zinc ore for this period, we have the statement of Mr. Rozier that the first 13 car-loads were shipped from the Valle mines in December, 1869. These we estimate to be equivalent to 200 tons.

For the years 1870 to 1879 we have the Census figure of \$37,760 as the value of the lead ore produced in the county. This we estimate to be equivalent to 944 tons of ore or about 700 tons of lead. For the productions of the Valle and Bonne Terre mines we have the figures of the tables referred to on the preceding pages. In 1877 the Dealoge mines started operations; their outputs are also given in the mine descriptions. Other diggings were worked in the county during the decade. The total lead production is, hence, obtained as follows:

Valle mines	1,944 tons lead	Dealoge works	3,570 tons lead
St. Joseph Lead Co.....	17,451 "	Other mines	1,035 "
		Total.....	21,000 "

For the zinc ore we make use of the table of productions of the Valle mines between 1870 and 1890, given in the mine descriptions. From this we see that the total for the decade was 26,512 tons.

For the years 1880 to 1893 we begin with the figures of the Tenth Census, which allow for the county production in 1880, 9844 tons of lead ore (about 6600 tons of lead) and 2239 tons of zinc ore. The productions given in Valle mines tables for this period we credit to Jefferson county, as has been seen. The St. Joseph Lead company produced 94,727 tons of lead from 1880 to 1890, while the Doe Run lead mines, which began work in 1888, produced up to and including 1890, 11,600 tons. During 1880 to 1886, the Dealoge mine yielded 38,830 tons of concentrates, equal to about 27,000 tons of lead. For the year 1889, the Eleventh Census gives the following figures of county production:

Lead ore, 28,514 tons; valued at \$1,014,462.
Zinc ore, 2,310 " " " 23,100.

These figures, without doubt, include the output of the Valle mines.

For the years 1889 to 1893 inclusive, the State Mine Inspector gives the following figures, which include the Flat river, but do not include the Valle mines output:

	Years end June 30.	Tons lead.	Total value.
1889		19,465	\$1,449,321
1890		16,900	1,232,000
1891		16,537	1,311,961
1892	23,740 tons ore=about	16,618	1,296,204
1893	20,349 " = "	14,244	1,100,000

We thus obtain for the total output of the county the following results:

1880 to 1890 .. St. Joe Lead Co. and Doe Run	106,327 tons lead.
1880 to 1886 ... Dealoge works	27,000 " "
1891 to 1893 ... Mine Inspector	47,399 " "
1880 to 1890 ... Other mines	1,274 " "
Total	182,000 " "

As the output of the Valle mines for this period is credited to Jefferson county, no zinc appears here.

Ste. Genevieve County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
Before 1850.....	50*	\$2,000	32	\$2,880	.....	.....	.....	.....
1850 to 1859.....	700*	28,000	490	52,920	.....	.....	.....	.....
1860 to 1869.....	.....	.....	.....	.....	.....	.....	.....	.....
1870 to 1879.....	300*	25,000	350	41,300	.....	.....	.....	.....
1880 to 1892.....	.....	.....	.....	.....	.....	.....	.....	.....
Totals.....	1,250	55,000	872	97,100	.....	.....	.....	.....

In Ste. Genevieve county, the Avon mines are about the only ones that have produced ore. Work was begun here in 1848. About 8 tons were produced in that year. Up to 1856, Dr. Shumard states that some 75 tons had been produced. Between the years 1848 and 1858, the greater part of mining was apparently done here, and, according to Judge G. W. Griffith, of Avon, about 750 tons of ore were produced during these years. The mines were then abandoned, and work was not resumed until 1872. Between that year and 1874, Judge J. E. Boyd, of Avon, estimates that about 500 tons of ore were raised. Dressing works and furnaces were erected at that time, and preparations were made for a large production.

Texas County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
Before 1880.....	10*	\$500	7	\$826	.....	.....	.....	.....
1880 to 1893.....	1*	43	1	57	1*	\$10	.....	\$33
Totals.....	11	543	8	883	1	10	.....	33

Some little mining has been done in this county in past years, probably in the early seventies. No records of productions at that time have, however, been obtained. About the year 1889, the Cabool mine produced about 2½ tons of zinc ore and some 300 lbs. of lead ore.

Washington County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1725 to 1799....	19,000*	\$760,000	9,500	\$950,000	.....	.....	.....	.....
1800 to 1819....	28,500*	1,140,000	17,100	1,539,000	.....	.....	.....	.....
1820 to 1829....	16,130	645,000	10,000*	1,000,000	.....	.....	.....	.....
1830 to 1849....	38,460	1,538,400	25,000*	2,250,000	... ..	.....	.....	.....
1850 to 1859....	18,555	742,200	13,000*	1,404,000	.....	.....	.....	.....
1860 to 1869...	4,285	257,100	3,000*	510,000	.....	.....	.....	.....
1870 to 1879....	13,000*	650,000	9,100	1,073,800	10,000*	\$100,000	3,333	\$490,000
1880 to 1893....	23,000*	959,000	16,100	1,320,200	4,000*	48,000	1,333	133,300
Totals.....	160,930	6,721,900	102,800	10,047,000	14,000	148,000	4,666	533,300

This county was the scene of some of the earliest mining in the state. For data concerning productions, we are dependent entirely upon scattered notes contained in Austin's, Schoolcraft's and Litton's writings, already referred to, and also to several volumes of the Public Lands reports.

Mine Renault was discovered about 1725, and was worked up to 1742. It then lay idle until the last years of the century. Old Mine was discovered about the same time and actively worked up to 1742, and more feebly from then to 1762. In the last year of the century, operations were also resumed here.

Mine a Burton was discovered in 1763, and was worked continuously to the end of the century. At times, the production was as high as 1800 tons of ore annually. Between 1798 and 1803, Austin places the production at 300 tons of ore annually.

From this data, we estimate the following productions:

Mine a Renault, 20 years.....	1,000 tons of ore.
Old Mines, 40 ".....	2,000 " "
Mine a Burton, 37 ".....	15,000 " "
Other mines.....	1,000 " "
Total.....	19,000

Mine a Burton continued worked from 1800 to 1804, at the rate of about 300 tons of ore per year. Between 1804 and 1808, it is credited with a production of 400 tons of ore per annum, thence to 1818 with a production of 250 tons of lead; in 1819 the production was probably as much as 500 tons of ore. After this it began to decline.

Old Mines produced at the rate of about 100 tons of ore in 1804, and work was done here for some years afterward.

Mine a Martin was discovered in 1803, and reopened in 1814, when large quantities of ore were mined.

New Diggings were discovered in 1806, and produced for a few years at the rate of 1000 tons of ore per year. They were abandoned about 1815.

The Shibboleth mine was discovered in 1811, and produced about 2500 tons of ore in that year. In 1819 they were producing at the rate of 500 tons of ore. In 1814 the Fenchurch a Courtola

and Richwoods mines were started, and produced small quantities. In addition to these, there were a number of small mines working, which we may allow a production, up to 1816 inclusive, of about 1000 tons.

For the three years, 1817 to 1819, Schoolcraft gives a list of 24 mines, which produced together in these three years about 4000 tons of lead, or, say, 6000 tons of ore.

From these notes we obtain the total ore production of the county, 1800 to 1819, as follows:

Mine a Burton, 17 years	6,400 tons ore.	Richwoods and F. Courtois 3 y'rs.	500 tons ore.
Old Mines, 9 years	600 "	Other small mines, 17 years	1,000 "
New Diggings, 10 years	6,000 "	24 mines, 1817 to 1819, 3 years...	6,000 "
Shibboleth, 6 years.....	8,000 "	Total	28,500 "

Between 1818 and 1825, the production of the Missouri mines, which were mainly in Washington and St. Francois counties, is estimated to have averaged at least 2000 tons of lead ore per annum. In 1823, the total production of Washington and St. Francois counties is placed at 2500 tons of lead; that of 1825 at 2100 tons. From July 1825, to September 1826, the output is placed as high as 5000 tons of lead. For the seven years, 1824 to 1830, Dr. Litton states that 5528 tons of lead were shipped from Selma. This does not include the production of the Valle mine, nor the shipments from Herculaneum, and the amounts hauled directly to St. Louis.

The conditions indicate something of a falling off in the Washington county and an increase in the St. Francois county outputs. Close figures it is impossible to obtain. As a general estimate, however, we take it that an allowance of 1000 tons per year is not far from the truth.

In 1831, 200 persons were employed at the F. Courtois mines. Between 1830 and 1850, Old mines and Shibboleth were worked, though the output was much reduced in later years. Other diggings were Belle Fontaine, Cannon, Burke, New Diggings, Shore, La Beaume, French and others. The last produced from 150 to 250 tons of lead ore between the years 1844 and 1850. The La Beaume mine is said to have yielded between 100 and 300 tons of ore per annum for 30 years, up to 1854.

Dr. Litton gives a list of the productions of 14 furnaces, from which we extract the following:

1841.....	503 tons lead	1846	1356 tons lead.
1842	816 " "	1847.....	1191 " "
1843.....	1366 " "	1848.....	1352 " "
1844	1355 " "	1849	1312 " "
1845.....	1437 " "		

Dr. Litton confesses that this table is incomplete as regards some important furnaces, as for the earlier years data were not available. For the later years the returns were from the books at three principal shipping points, while from the others figures were not obtained.

For this decade, we hence make the following allowance:

1830 to 1841	1,100 tons ore per year=13,000 tons lead.
1842 to 1849	1,500 " " =12,000 "
Total	25,000 "

In 1855, Swallow gives 21 mines and 14 furnaces as operating in the county. In 1854, little work was in progress at Old mines, and some 20 men were employed at Shibboleth. Some 15 other mines were in operation.

From Dr. Litton's statement of furnace productions, we extract the following:

1850	1,106 tons lead.	1853	1,050 tons lead.
1851.....	1,147 "	1854.....	990 "
1852.....	1,118 "		

The remarks concerning the imperfections of the preceding table apply here also. A diminution of the production is indicated. As a general estimate, we think an allowance of 1300 tons of lead per year a fair one for this decade.

For the years 1860 to 1869 we have been able to obtain absolutely no records of productions or other notes indicative of the status of mining. That during the period of the war, little or no work was done, is, however, probable. Afterward operations were probably resumed, with the increase in the price of lead. We hence allow for this period a production of 3000 tons of lead.

For the year 1870, the Census values the lead ore production of Washington county at \$17,000. This, at \$50 per ton, is equivalent to 340 tons of ore. For 1830, the Census figures are 1185 tons of lead ore and 606 tons of zinc ore.

Flynn's furnace at Richwoods produced the following amounts:

1877	89 tons of lead.
1878	74 " "
1879	117 " "

In 1872, Broadhead [32, pp. 697, 698] reports that 1659 tons of zinc ore and 2200 tons lead ore were shipped from Washington county. According to the Mines, Metals and Arts, there had been smelted:

At Webster, Palmer and Harmony furnaces, up to April 1, 1874	12,500 tons of pig lead.
From the old Perry furnace were shipped up to April, 1874	112 " "
From the Long furnace at Old Mines, in 1873	214 " "
From the White smelter at Old Mines, in 1873	74 " "

With these and other Washington county furnaces, it must be remembered that small amounts of ores from adjacent parts of other counties are probably represented.

According to Williams [238], the Hopewell furnace produced in 1875, 156 tons of lead. Washington county in the same year produced 1,566 tons of lead and zinc ores. There were probably produced in Washington and other counties in that year 4500 tons zinc ore.

Between 1872 and August, 1891, the following were the productions of different furnaces of the county, according to statements furnished by operators:

	Tons lead ore.		Tons lead ore.
J. P. and R. M. Bugg, Potosi	7,443	Allowed for missing mines and for years	
James O. Long	2,850	1870, '71, '92 and '93	7,359
Palmer Lead Co.	10,358	Total for 1870 to 1893, inclusive.....	361,000
Charles Moran, Richwoods.....	1,900	Allow for years 1870 to 1879	13,000
Mrs. Thomas S. White.....	5,700	Balance for 1830 to 1833.....	23,000
Kingston furnace	366		
Abbeyville Mining Co.	25		
Total.....	28,642		

From the notes above given, we think an allowance of 10,000 tons of zinc ore for the years 1870 to 1879 a fair one.

For the years 1880 to 1892 we have already given figures. In addition, we present the following table, extracted from the Census and mine inspector's reports:

U. S. Census:	Tons lead ore.	Tons zinc ore.
1880	1,185	660
1889	1,074= \$27,706	
State Mine Inspector, years ending June 30:		
1889	3,800	125
1890	1,200	
1891	1,850= 83,130	
1892	1,794= 81,088	
1893	877= 27,805	

In 1887, the mine inspector reports that the Palmer mines were producing at the rate of 500 tons of ore per year; and the Union M. & S. company, J. Long and Old Mines at the rate of nearly 700 tons.

LEAD AND ZINC DEPOSITS OF MISSOURI.

Webster County.

Period.	Lead.				Zinc.			
	Ores.		Metal.		Ores.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1830 to 1849.....	300*	\$12,000	195	\$17,550	.....	.....	.....	.....
1850 " 1859.....	100*	4,000	70	7,560	.....	.....	.....	.....
1860 " 1869.....	200*	12,000	140	23,800	.....	.....	.....	.....
1870 " 1879.....	300*	15,000	210	24,780	.....	.....	.....	.....
1880 " 1893.....	200*	8,600	140	11,480	.....	.....	.....	.....
Total.....	1,100	51,600	755	85,170	.....	.....	.....	.....

As stated in the mine descriptions, work apparently began in this county as early as 1840, and about 150 tons of ore were mined at the Hazelwood diggings. A few other mines were also worked, but the product was not large. For the ten years preceding the war we can make only an approximate estimate, and for the years 1860 to 1869 the same. According to the figures of the Census, the production of lead ore in Webster county, in 1870, was valued at \$1980, equivalent to about 40 tons of ore. For succeeding years we have no figures, and our estimates are entirely hypothetical.

Wright County.

Period.	Lead.				Zinc.			
	Ore.		Metal.		Ore.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1870 to 1879.....	330*	\$16,550	231	\$27,258	700*	\$7,000	233	\$28,000
1880 to 1893.....	.....	.....	.....	.....	600*	7,200	200	20,000
Totals. ....	.....	.....	.....	.....	1300	14,200	433	48,000

Figures of productions of Wright county mines are given in some detail in the mine descriptions, and the reader is referred to these for the data upon which the estimates of the table are based.

From these county statistics are prepared the summaries of the following two tables. In addition, by direct reference to the annual yields of individual mines, and to the annual productions of camps and of the whole state, given in the preceding notes, tables of annual productions of ores since 1870 have been prepared, and are incorporated in the general tables of states on pp. 254-256, of chapter VI of this report.

TABLE OF TOTAL STATE PRODUCTIONS, BY COUNTIES.

From the beginning of mining to the end of 1893.

Counties.	Lead.				Zinc.			
	Ore.		Metal.		Ore.		Metal.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1 Barry	160	\$6,950	112	\$9,436	1,200	\$14,400	400	\$40,000
2 Benton	400	21,500	280	38,500	10	120	4	480
3 Camden	700	32,000	45	54,010	.....	.....	.....	.....
4 Christian	5,500	262,000	3,850	413,420	500	6,000	165	16,500
5 Cole	3,900	184,500	2,705	299,080	.....	.....	.....	.....
6 Cooper	180	6,800	91	11,830	.....	.....	.....	.....
7 Crawford	2,700	122,600	1,865	213,490	.....	.....	.....	.....
8 Dade	2,140	102,568	1,499	160,718	13,000	140,000	4,330	486,300
9 Dallas	700	39,300	480	73,600	.....	.....	.....	.....
10 Franklin	37,450	1,620,000	25,402	2,647,580	.....	.....	.....	.....
11 Greene	94,000	444,300	6,580	684,040	5,700	123,400	2,445	246,100
12 Hickory	475	25,550	333	45,774	50	600	16	1,600
13 Jasper	232,300	10,753,000	162,610	16,114,700	851,000	18,142,000	364,390	36,903,000
14 Jefferson	26,663	1,165,150	18,077	1,854,254	33,561	408,732	11,520	1,172,000
15 Lawrence	25,867	1,132,946	18,107	1,487,294	83,711	1,240,962	30,601	3,060,100
16 Madison	147,340	6,613,618	97,704	9,929,208	.....	.....	.....	.....
17 Marlee	100	5,000	70	8,260	10	220	4	400
18 Miller	2,200	110,300	1,550	184,020	.....	.....	.....	.....
19 Moniteau	2,500	108,450	1,690	175,760	500	11,000	215	21,500
20 Morgan	3,500	176,600	2,480	292,710	60	1,820	26	2,600
21 Newton	77,285	3,560,400	54,100	5,998,200	183,000	2,096,000	61,000	6,433,300
22 Perry	575	27,800	399	48,110	.....	.....	.....	.....
23 Saline	300	13,600	210	19,740	.....	.....	.....	.....
24 St. Francois	353,811	14,817,150	245,000	22,860,000	26,712	267,120	8,904	891,700
25 Ste. Genevieve	1,250	55,000	872	97,100	.....	.....	.....	.....
26 Texas	11	543	8	883	1	10	.....	33
27 Washington	160,330	6,721,900	102,800	10,047,000	14,000	148,000	4,666	533,300
28 Webster	11,000	51,600	755	85,170	.....	.....	.....	.....
29 Wright	330	16,500	231	27,258	1,300	14,200	433	43,000
Totals	1,099,768	48,737,670	750,355	73,881,395	1,215,315	22,614,084	489,119	49,823,113

LEAD AND ZINC DEPOSITS OF MISSOURI.

TABLE OF TOTAL STATE PRODUCTIONS, BY PERIODS.

	Lead.				Zinc.			
	Ore.		Metal		Ore.		Metal.	
	<i>Tons</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1720-1799.	36,000	\$1,440,000	18,000	\$1,800,000	.....	.....	.....	.....
1800-1819.	42,200	1,689,000	25,300	2,280,000	.....	.....	.....	.....
1820-1829.	80,800	1,231,000	19,100	1,908,000	.....	.....	.....	.....
1830-1849.	112,900	4,516,000	78,400	6,604,000	.....	.....	.....	.....
1850-1859.	73,100	2,923,000	51,100	5,526,000	.....	.....	.....	.....
1860-1869.	45,100	2,706,000	31,600	5,370,000	200	2,000	100	\$8,000
1870-1879.	229,500	11,476,000	160,700	18,961,000	156,400	\$1,680,000	56,000	6,524,000
1880-1893.	530,200	22,756,000	371,100	31,432,000	1,058,700	20,932,000	433,000	43,291,000
	1,099,800	48,737,000	750,300	73,881,000	1,215,300	22,614,000	489,100	49,823,000

PART III.

Missouri Lead ^{AND} Zinc Mines

A systematic and detailed description of the important developments
and occurrences of lead and zinc ores.

*To accompany the report of Arthur Winslow
on the Lead and Zinc Deposits of Missouri.
Vols. VI and VII Reports Missouri Geological Survey 1894.*

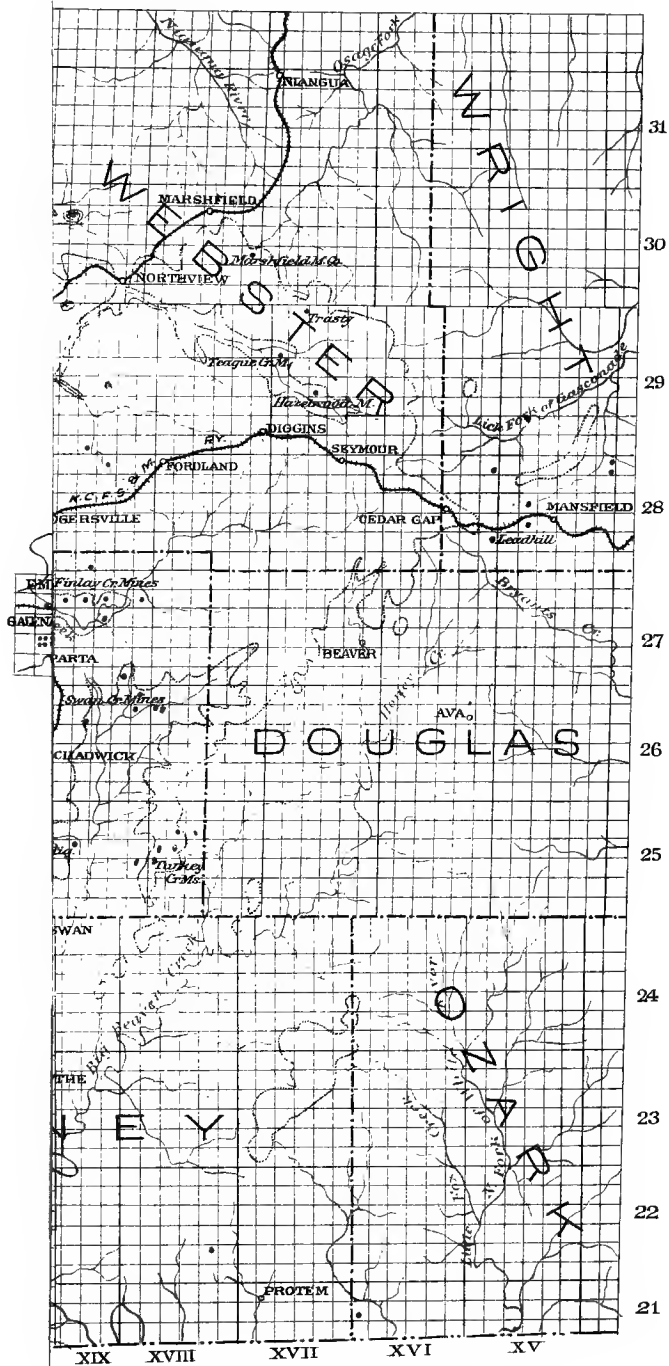


FIG. 1.

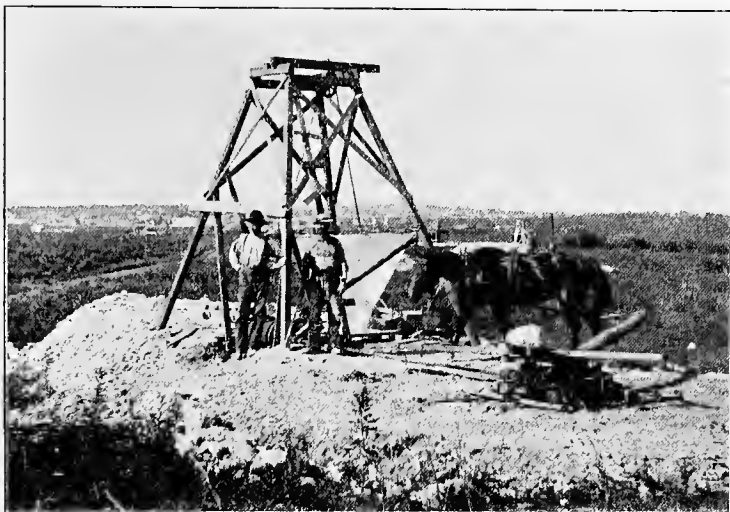


FIG. 2.



VIEWS OF MINING PLANTS IN SOUTHWEST MISSOURI.

FIG. 1. A PROSPECTORS' OUTFIT.

FIG. 2. A COMPLETED PLANT.

From photographs by W. P. Jenney.

CHAPTER XIV.

THE MINES OF THE SOUTHWESTERN DISTRICT.

THE JASPER COUNTY SUB-DISTRICT.—THE NEWTON COUNTY SUB-DISTRICT.—THE LAWRENCE AND BARRY COUNTY SUB-DISTRICT.—THE GREENE AND WEBSTER COUNTY SUB-DISTRICT.—THE CHRISTIAN COUNTY SUB-DISTRICT.—THE WRIGHT COUNTY SUB-DISTRICT.—THE DADE COUNTY SUB-DISTRICT.—OUTLYING DEPOSITS IN THE SOUTHWESTERN DISTRICT.

The Southwestern district, as here defined, includes the mines of nine different counties. For convenience of discussion, this district is further separated into certain sub-districts, this separation being controlled partly by county lines and partly by the characteristics of the deposits. Within the boundary lines of these divisions, a study of the accompanying district map reveals the fact that the mines are bunched about certain centers, in such a way as to admit of their being again separated into what we will call "camps," which, though loosely tied together by scattered deposits, are yet quite distinct. The primary divisions which we thus recognize in the Southwestern district are as follows:

1. The Jasper county sub-district.
2. The Newton county sub-district.
3. The Lawrence and Barry county sub-district.
4. The Greene and Webster county sub-district.
5. The Christian county sub-district.
6. The Wright county sub-district.
7. The Dade county sub-district.

The mines of these sub-districts we shall now describe in the order given. For the sake of completeness we shall introduce, in addition to the results of recent examinations, abstracts of descriptions already published of mines since abandoned and now inaccessible, which were of importance and which serve as valuable illustrations.

THE JASPER COUNTY SUB-DISTRICT.

The Jasper county sub-district, as here defined, covers townships 27 N., 28 W. and the southern half of 29 N., ranges 31 W., 32 W., 33 W. and 34 W., including, thus, mines just south of the Jasper county line, in Newton county, and also the mining camp of Galena, Kansas. As belonging to this sub-district may also be regarded the recent developments at Spring City, in Newton county, section 10, township 26 N., 33 W.

Reference to the description of the stratigraphy and to the discussion of the ore deposits of southwestern Missouri, in preceding chapters, will show that the ore bodies of this sub-district are in Lower Carboniferous rocks which are practically horizontal. These are composed, normally, of crystalline, white limestone, carrying abundant crinoids remains, and other fossils. With these beds are associated varying proportions of chert, which is sometimes disposed in nodules, following generally the stratification, sometimes in lenticular layers, and sometimes in massive bodies. A preponderance of chert has been observed at the lower levels, in exposures along the larger streams, where great bodies frequently crop out; these are shown, however, not to be persistent. In the vicinity of the ore bodies, the limestone country rock is much decomposed and often dolomized. The extent of the decomposition is variable; sometimes, only occasional pinnacles or ridge-like masses, called "bars," are left; sometimes, a limestone stratum stretches, roof-like, over the ore body. Overlying these Lower Carboniferous rocks, and occupying depressions in them, are frequent limited patches of Coal Measure shales and sandstones, often containing coal beds of workable thicknesses.

The ore bodies proper are brecciated masses of irregular form, of no prevailing trend, but generally of greater horizontal than vertical extent. They are composed principally of the residuary products of decay of Lower Carboniferous limestones, largely chert, but also of Coal Measure shales and sandstones, with occasional fragments of coal. The fragments of these materials are surrounded by a matrix, consisting of comminuted particles of the same, or of plastic clay or mud; frequently this matrix is solidified, sometimes through the deposition of lime, forming an impure limestone, and more often, through the deposition of silica, forming an impure chert. The metalliferous minerals are diffused through this matrix or occupy cavities between the fragments.

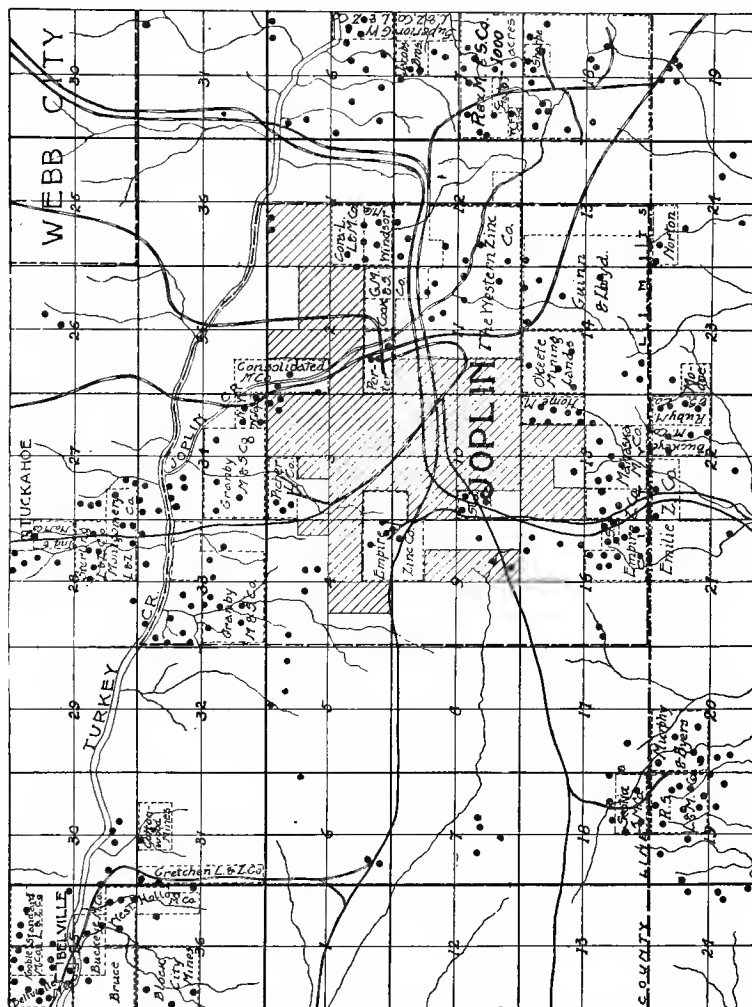
The compounds of lead and zinc are principally galena and blende; their oxidation products are comparatively rare in this sub-district. The most common associated minerals are dolomite, calcite and marcasite.

Though certain groups of mines are along the lower levels of the country, the deposits are characteristically distributed upon the divides between the larger streams; the Joplin, Webb City and Galena camps being notably so located. Individual mines may be in or adjacent to the minor depressions; but, in a large sense, the deposits characterize the uplands rather than the lowlands.

A noteworthy feature of this sub-district is that the ores are bunched about certain centers and are not uniformly distributed over the area, and in many cases no connection can be traced between such groups of deposits.

JASPER COUNTY SUB-DISTRICT.

Within the Jasper County sub-district, we distinguish certain camps of mines gathered around different towns or places. The most important are about Joplin, Webb City and Cartersville, Carthage, Oranogo, Ileville, Saginaw, Scotland, Spring City, and Galena, Kansas. The ore d



These camps we will now proceed to describe, giving chief prominence, as those most important mines recently studied by the Geological Survey, but making reference also to mines previously described by others which are accessible.

The productions and relative importance of the different camps can be judged from the following tables of productions during recent years:

TABLE OF PRODUCTIONS OF JASPER COUNTY SUB-DISTRICT, BY CAMPS, FROM 1886 TO 1893 (IN TONS.)

	1886.		1888.		1889.		1890.		1891.		1892.		1893.	
	Lead ore.	Zinc ore	Lead ore.	Zinc ore.	Lead ore.	Zinc ore	Lead ore.	Zinc ore.	Lead ore.	Zinc ore	Lead ore.	Zinc ore	Lead ore.	Zinc ore.
Joplin	3,302	22,208	2,386	11,299	2,511	19,515	2,861	19,417	4,270	32,113	6,021	27,672	4,468	30,972
Webb City and Car- terville	2,980	24,019	2,007	24,745	3,614	41,588	3,820	41,149	3,863	50,641	4,531	62,655	3,460	55,169
Lehigh	25	3,212	.....	5,297	.....	3,600	12	2,945	.....	1,538	.....	1,521	.....	.....
Sherwood .....	.....	.....	.....	492	.....	487	.....	.....	3	478	3	76	.....	.....
Oronogo	572	865	168	718	.....	.....	225	788	233	1,030	407	4,987	2,147	523
Carthage .....	.....	455	.....	36	.....	.....	.....	.....	.....	1,805	.....	2,114	.....	360
Belleville .....	.....	.....	153	12,745	.....	8,574	92	7,603	37	4,189	102	5,636	3	530
Golena, Kas	2,962	27,275	2,642	27,275	3,617	33,575	4,174	21,675	3,602	20,642	7,188	23,812	.....	.....

NOTES.—The figures for 1886 were obtained from Wilson's pamphlet [242]. For 1887 no data were obtained. For 1888 and 1889 the figures of zinc ore were furnished by Mr. Chas. Gruengerich; lead ore for 1888 was calculated from the tables of weekly production of Mr. J. A. Zook; for 1889 they were estimated. For the years 1890-93, the figures are those of the State Mine Inspector. In Joplin are included the Roaring Springs, Tuckahoe and Scotland camps.

THE JOPLIN CAMP.

The mines belonging to this camp are mostly included within the city limits of Joplin, an area of about 12½ square miles, extending from Turkey creek on the north, southward to the county line, with a breadth of 3½ miles. Beyond these limits to the east are further included the mines of what is known as the Thousand Acre tract; to the southwest the Roaring Springs group of mines, and to the north, just beyond Turkey creek, the Tuckahoe mines. A few other outlying mines of contiguous country will also receive notice under this heading. The map of p. 545 shows the outlines of the camp, the location of the principal mining tracts and the distribution of openings during recent years.

This is one of the foremost camps, not only of Jasper county, but of the entire Southwestern district. Sufficient of its history has already been recited, for the fact to be apparent. Beginning with desultory mining about 1850, it sprang into prominence not until the year 1870, with the discoveries on the Moon tract, now within the town limits. From a production of a few hundred tons in that year it

has risen to many thousands at present, and a town with multiplied industries has grown up. During these years of its history, a vast number of mines or diggings have been operated about Joplin, and the openings at some localities almost touch each other over many acres. The density of mining along Joplin creek as early as 1873 is well illustrated in the adjacent, cut reduced from the map accompanying Schmidt's report of that year. On land maps of the district issued by Mr. J. R. Holibaugh, M. E. of Joplin, in 1892, from which figure 116 of the preceding page is prepared, 115 different mines, each probably representing several openings, are located within the town limits, and a dozen or so beyond these; many more have undoubtedly been dug in past years. It is manifestly

Map of the study area showing the distribution of *S. b. curms* and Lead Furnace. The map includes the York River, York L.P.C.A., and various locations like Lead Furnace, S. b. curms, and York L.P.C.A. The map is divided into a grid. A scale bar indicates 1 inch = 1 mile.

FIG. 117. Density of mining, Joplin cr. 1873
From map of A. Schmidt, Report 1873-74.

and still more so to attempt their description. Many are long since abandoned, and no records are preserved, if kept; others are mere shallow pits, the scenes of a few weeks' work. Similarly, with regard to the mapping of the mines, much detailed field work and sheets on large scales would be necessary in order to locate all of the openings. On the district maps accompanying this report, only general locations can be attempted. Topographic maps on a much larger scale have been drawn, and were to have been issued with special reports as soon as the means were provided.

THE EAGLE MINES.

In the southwestern corner of the camp, in the SE. $\frac{1}{4}$ of section 16 and the SW. $\frac{1}{4}$ of section 15, is a group of diggings of which the Eagle mines of the Empire Zinc company are the center. Adjoining these to the east, and in similar ground, are the mines of the Mshsks Mining company, and to the west those of the Snyder Brothers. Immediately across the county line to the south are the mines of the Emilie Zinc company. These belong to the same group.

As showing the extent of these mines, the following figures of production are given:

	Eagle.*		Mahaska.†		Snyder Bros.‡	
	Lead ore	Zinc ore.	Lead ore.	Zinc ore	Lead ore.	Zinc ore.
	Tons.	Tons.	Tons.	Tons.	Tons.	Tons.
1887 to 1889.....						
1889.	47	1,610		10		
1890.	338	3,934		1,163		417
1891.....	220	6,274			355	7,358
1892.....	1,084	4,236	451	882	110	2,866
1893.....	418	2,694				

* From figures furnished by Empire Zinc Co. Those for 1893 include only 4 months operation.

† From J. R. Holibaugh.

‡ From the state mine inspector's reports, and refer to the year ending June 30.

This group of mines is situated at the head of a hollow leading down to Shoal creek, following a small tributary which flows into that creek at Grand falls. This fact of topographic location is indicated on the district map, and is clearly shown on the topographic map prepared by the Survey. In the figure of the opposite page, the distribution and shape of the underground workings are shown, the illustration being reduced from the company's mine maps. Though part of these excavations were in barren ground, their outlines are quite closely those of the ore bodies, and hence the illustration is a very instructive one.

The mines occupy the ground of the early Corney diggings. As described by Schmidt [32, p. 444] in 1873, these diggings consisted of a number of shafts sunk to depths of about 20 ft., through loose fragments of chert and disturbed layers, overlying decomposed dolomite, in which were imbedded fragments of chert and streaks of blende 1 to 3 inches thick. Associated with the chert, blocks of sandstone were found. In one shaft, bluish limestone was encountered, containing bitumen at a depth of 20 ft. The Badlong diggings, also described by Schmidt, were a fourth of a mile north of the Corney. Cerussite was found here in the red surface clay.

Shaft No. 25 of the Eagle mines, at the time of visit, was operating two drifts or levels at depths 55 and 75 ft. respectively. The workings of the upper level followed generally an E-W. direction, while in the lower level they lay more nearly N-S. The ore occurred in horizontal "runs," which are ill-defined oblong bodies of irregular sections—sometimes expanding in cross-section to form chambers—the contents of which merge into the surrounding barren ground. This barren ground was in composition often the same as the gangue of the ore bodies proper, and consisted largely of chert. The chert occurred generally in slabs, and sometimes in roughly spherical masses. The slabs were evidently remnants of lenticular layers or thin strata, and sometimes extended across or over an entire ore body, forming the roof of large chambers; elsewhere they dipped strongly, the strike being frequently parallel to the run of ore.* This chert was of the white or bluish variety of the country rock, extremely fragile, a sharp blow of the hammer shattering a large mass into numerous fragments.

In and around these slabs and blocks of chert was a matrix of granular dolomite, more or less decomposed, associated with red tallow clay, sometimes occurring in large masses. Some portions of this matrix were partially silicified, forming a somewhat soft and impure, dark secondary chert. In one part of the mine, barite was found in a crystallized condition in sufficient quantities to interfere with the milling of the blende; this is, however, an exceptional occurrence, barite being rare in the mines of this district. Through this gangue the mineralization appeared to follow cer-

* Mr. Pope Yeatman, the mining engineer of the company, expressed the opinion that, where such dips converge, as in a shallow syncline, produced probably through settling, ore is liable to be found.

tain axes, though spreading varying distances from them. The ore deposit proper is, thus, not a distinct body, as if introduced into a pre-existing cavity, but is, more exactly speaking, an impregnated portion of a brecciated and dolomized mass.

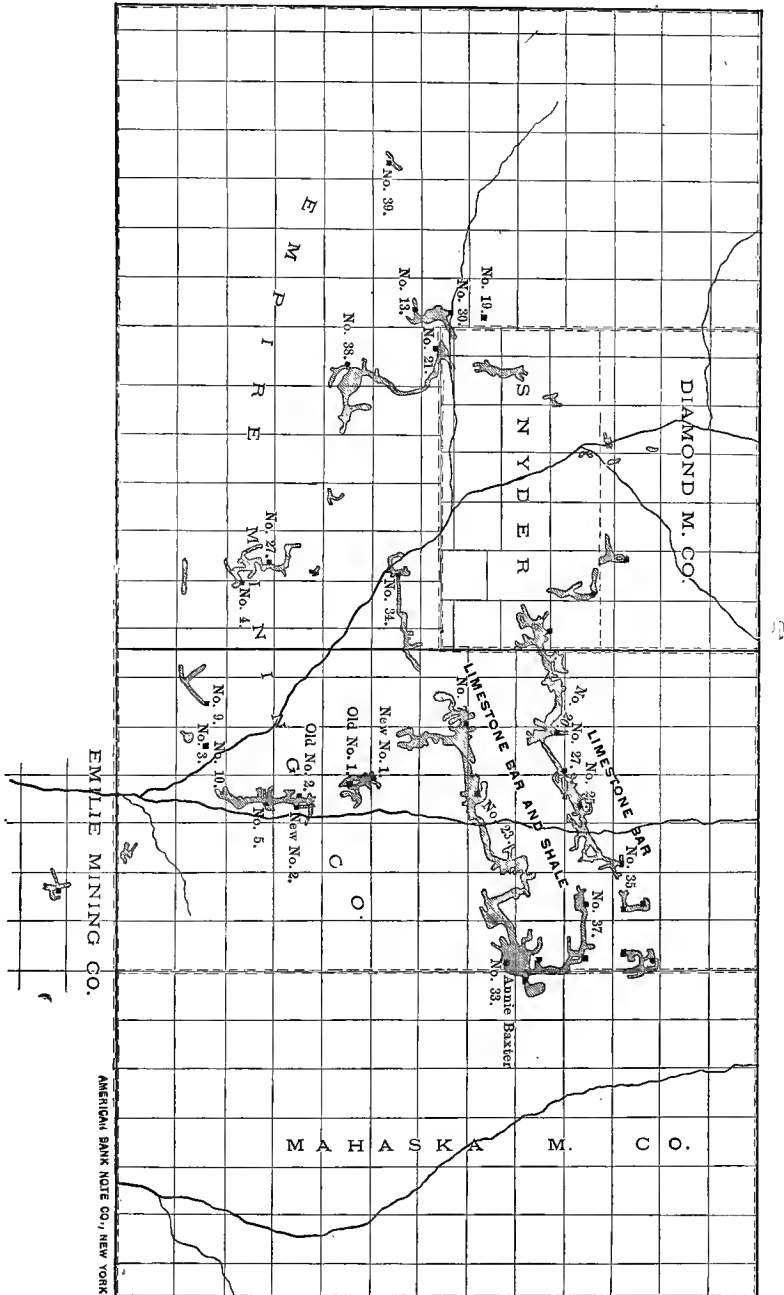


FIG. 118. Map of the Eagle Mines of the Empire Zinc company, from surveys made by the company. Scale, 1 inch=800 feet.

The metalliferous constituents of the ore were principally blende, but a good deal of galena was also found. The crystals of these minerals were disseminated through the decomposed dolomite or clay, or through the dark secondary chert, or they were attached to the surfaces of the fragments of original chert. This mineralized portion was frequently a mere string, while elsewhere it spread out to a large body. In such cases, if the gangue was soft, the whole ore body could be shoveled out, leaving large chambers, sometimes as much as 150 ft. across. The zinc contents of these ores, as taken from the mines, ranged from $10\frac{1}{2}$ to $12\frac{1}{2}$ per cent, the moisture from 17.3 to 22 per cent, the balance being gangue. From the relative output of lead and zinc ores, the lead contents is probably below 1 per cent. The dressed zinc ore contained from 60 to 62 per cent of metallic zinc, and at times reached as much as 66 per cent.

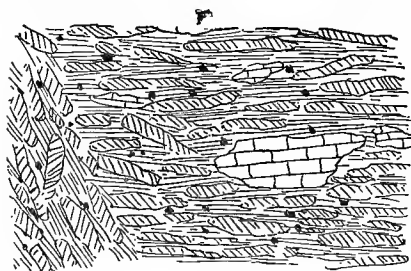


FIG. 119. Sketch showing disturbed condition of ore body at Eagle mines.

The prevailing course of the ore run is a little N. of E., and it is in direct continuation of the upper run of No. 23. The ore contains blende and a little galena; steel blende is especially abundant here; little or no pyrite was observed. The gangue is similar to that last described, with abundance of the earthy, secondary chert. The chert slabs are very much disturbed and dip in all directions, sometimes at steep angles. In one portion of the mine a pocket of Coal Measure shale and sandstone, such as are frequent in the district, was encountered. The adjoining figures (120) illustrate the conditions of its occurrence.

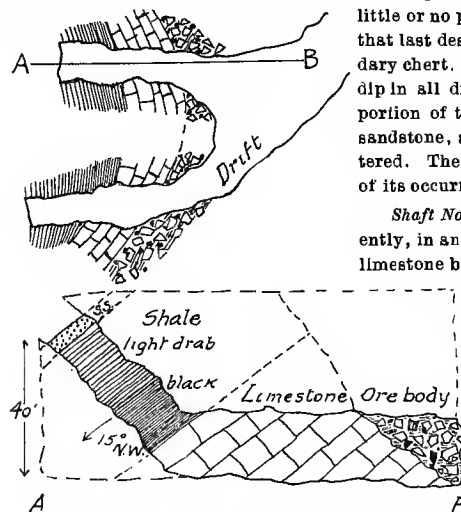


FIG. 120. Occurrence of Coal Measure shale and sandstone at the Eagle mines.

Shaft No. 25, about 400 feet north of No. 23, is, apparently, in another run of ore, separated from the last by a limestone bar. It is 90 ft. deep, with a drift at the bottom and one at 80 ft. The structure and composition of the ore body are similar to the last, with the exception that a larger amount of pyrite is present.

Snyder No. 3 Shaft, about a quarter of a mile west of the last, is 70 ft. deep. The ore consists of blende and galena, in a gangue composed of highly brecciated, white chert, enclosed in decomposed dolomite, and in a dark drab, hard, earthy chert, not unlike a granular argillite in texture. Dolomite crystals are frequently found imbedded in the earthy

chert, to the extent of constituting often a large part of its mass; these, on weathering out, leave a peculiarly pitted, tufaceous-looking rock. These two conditions are well illustrated in the plate opposite this page. Analysis No. 515 of the table on p. 447 is of this gangue.

The *Emilie Mine*, immediately south of the *Eagle mine*, began operations in the spring of 1890. It was visited by Mr. Robertson, and is described by him as follows: "The shaft is 100 ft. deep, the upper 85 ft. being in a mass of brecciated chert, and the lower 15 ft. in hard, compact chert. The ore found here is mainly blende, of a fair quality, partially cementing the fractured chert, the

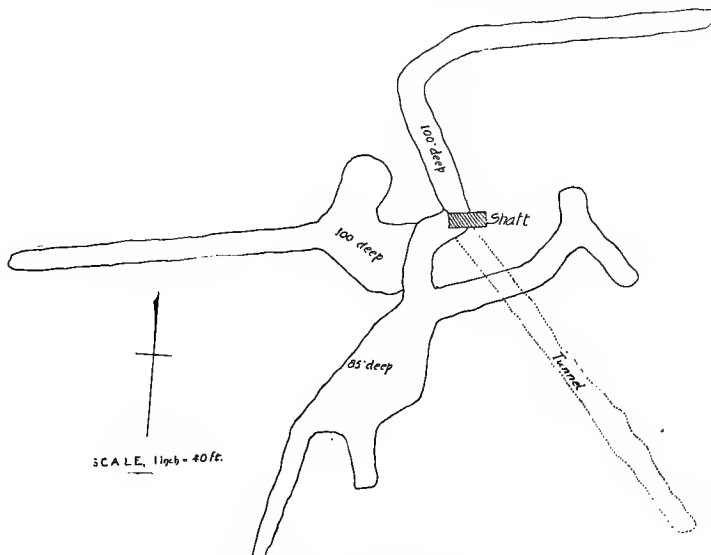


FIG. 121. Map of the Emilie mine.

interstices being filled and the whole being bound together by a dark brown secondary chert. Some "aillate" occurs in the upper portions of the workings, especially in the softer ground. Besides blende and calamine, few other minerals are present, though some marcasite and calcite occur.

The ore body appears to be a "run," which is about 20 ft. to 30 ft. in thickness, 20 ft. in width, and has been followed S. 20° W. for about 100 ft., by a drift. It lies between the levels of 65 and 90 ft. A drift has also been run for about 60 ft. to an air-shaft.

The chert in the upper part of the mine is light drab in color, and is very brittle. That occurring at a depth of 85 ft. is extremely tough and hard to drill; it is of a dark-blueish drab color, and lies in heavy benches; the secondary chert, which occurs in the ore, is of a brownish drab color, and very hard and tough; it fills all the interstices between the fragments of chert and ore, and renders crushing and jigging imperative. (See Anal. No. 364 of table on p. 447.) In some portions of the mine, the ground is less hard, and is thus interesting as an illustration of the way that both soft and hard ground may occur within narrow limits. Up to 1891, about 4000 tons of zinc ore had been produced."

Reviewing this group of mines, an inspection of the map on page 549 shows that the runs of ore at the different shafts follow certain lines or courses. One series of courses is plainly in an ENE.-WSW. direction, while another prevailing direction is approximately NW.-SE., nearly at right angles to the last. Further, among the peculiarities of the Eagle mines is the fact that they are located on a divide between two small hollows, though in a large sense they are in a depression. The ore bodies here are characterized generally by being much disturbed and open, are associated with much shattered chert, have no limestone roof and few limestone bars; the ground is also usually soft and easily mined. A predominance of blende over galena is also noticeable. Oxidized ores are remarkably scarce, considering the open nature of the ground; pyrite is not generally diffused, though it is found at a few places.

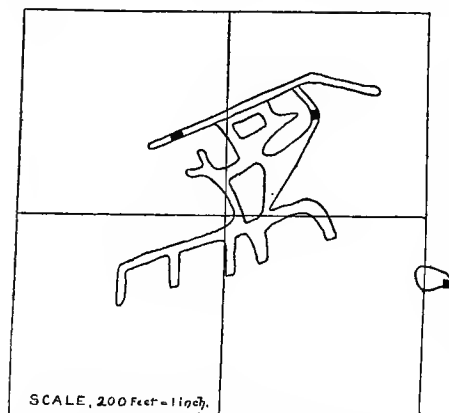


FIG. 122. Map of the Ruby mine.
From surveys by the company.

although more or less ore has been found, no bodies have as yet been struck sufficiently large to produce ore for shipment.

ROARING SPRING CO., HOME MINING CO. AND O'KEEFE MINE.

These companies control nearly a section of land lying between the Ruby mine and the city of Joplin. At the first mentioned, little more than prospecting has been done. On the Home Mining company's land the developments are somewhat larger, and ore has been mined, but not on an extensive scale. A little mining has also been done on the O'Keefe lands.

THE GUINN AND LLOYD MINES.

These lands cover the eastern half of section 14 and part of section 13, just south of Joplin. Many openings have been made upon them, and large amounts of ore have been produced. Prominent and of great interest among the mines of this tract is what is known as the Coon. This was an example of what are called circular mines, successive drifts having been driven, one under the other, in a complete circle around a barren core or cone composed largely of chert. The ore body, consisting of a soft incoherent breccia with a matrix of clay, lies in a sheet about this central mass. Surveys of this mine have been made by Mr. A. F. Donnan, C. E., of Joplin, but he was unable to furnish a copy of the map.

As a measure of the output, the following figures of production for the past few years are given:

	Lead ore.			Zinc ore.	
	Tons.	Values.		Tons.	Values.
1886	1,032	\$51,617	1886	1,144	\$16,209
1890a	172	8,256	1890a	1,027	28,243
1891a	186	9,630	1891a.	633	14,824
1892a	1,212	49,680	1892a.	1,973	43,415

a Reports State Mine Inspector.

THE NORTON MINING COMPANY.

This company owns the NW. $\frac{1}{4}$ of section 24, township 27 N., 33 W., thus adjoining the Guinn & Lloyd lands on the southeast. The mines, however, all lie near the middle of the south line of this section. This is within three miles of the city of Joplin, and even nearer to the Kansas City, Fort Scott & Memphis railway. Operations were commenced in 1886, and have continued with varying success to the present time. The mines are all situated in the upper limestones of

THE RUBY MINES.

Immediately east of the Emilie Zinc company's lands is a group of mines including the Ruby, Buckeye and Modoc. None of these were in operation at the time of examination of this district, and no underground observations could be made. The principal work has been done on the Ruby Mining and Smelting company's land, where several shafts have been sunk, and a good deal of ore has been taken out. The production from June, 1890, to June, 1891, was 784 tons zinc ore, sold for \$19,008. The adjoining cut illustrates the extent of the workings here.

THE MODOC COMPANY.

These mines are located in the SW. $\frac{1}{4}$ NW. $\frac{1}{4}$ section 23, T. 27 N., 33 W. Several shafts have been sunk in this land, but, although more or less ore has been found, no bodies have as yet been struck sufficiently large to produce ore for shipment.

the Lower Carboniferous formation. The ore consists mainly of blende of a good quality, occurring in a gangue, principally of dolomite. The mines were not in operation when visited, and, hence, neither sections of the shaft could be obtained nor could the occurrence of the ore in place be examined. There were six shafts, nearly all about 75 feet in depth, and one 120 feet. A new shaft was being sunk to a depth of 130 feet. Beside the blende, there are small quantities of galena noticeable. Marcasite and chalcopyrite occur in characteristic crystals. The order of deposition appears to be dolomite, blende, galena, marcasite and chalcopyrite.

The mines have not produced very heavily, the total output being placed at about 1200 tons of "jack" up to July, 1891.

THE WESTERN ZINC COMPANY'S LANDS.

The lands of this company, until 1893, were the property of the Oawego Mining company (since 1882); before this, they were worked by the Picher Bros. They are located on the head waters of Joplin creek, occupying most of section 11, and nearly all of the western half of section 12, township 27 N., 33 W. These lands have been operated for many years, and large quantities of ore have been produced from them. They have been worked almost entirely on leases and not by the company; hence, the individual operations have been generally small, and the output from any one opening not very large; moreover, only a few shafts are open at any time. As an indication of the productivity of these lands, the following partial table of productions is inserted here:

	Lead ore.		Zinc ore.		Total values.
	Tons.	Values.	Tons.	Values.	
1875a			1,800	\$24,939	
1876a	666		4,502	78,071	
1877a	1,664		2,027	22,072	
1878a	2,769		2,481	23,361	
1879a	1,762		2,145	31,458	
1880a	2,626		947	14,189	
1881a	1,443		347	4,915	
1882a	453		143	2,540	
1883a	217				
1884a	954				
1886b	1,143		1,226		
1889a year ends July 1	350		1,847		\$60,302
1890c " " June 30	64?				
1891a " " July 1	466	\$20,823	2,657	66,757	
1892a " " "	924	48,249	2,619	61,306	
1892a to Dec. 31.	657		1,244		59,947
1893a	1,148	45,526	931	16,003	

a Compiled from the company's books, by J. R. Holibaugh.

b Jno. N. Wilson [242, p. 32].

c Report State Mine Inspector.

A few shafts were examined here recently by the Geological Survey, with the following results:

The Gobar and Tomlinson shaft and the Barker shaft were situated in the NE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 11. The shafts were about 50 ft. deep, and were sunk through solid limestone and chert near the surface, reaching ore-bearing and more open rock at the bottom. The decomposition of the country rock is not very great, and the strata, in places, appear to be undisturbed, though, at times, they dip west fully as much as 30 degrees. In the drift at the bottom of the shaft, the limestone was seen to be highly dolomized, and in this rock are cavities or chambers, frequently large

enough to admit several men. These cavities are lined with beautiful and large crystals of calcite and galenite, and more rarely with sphalerite. Ore seems to be confined to the dolomized portion of the limestone. The gangue consists of this dolomite and of a gray, secondary chert or partly silicified sandy shale; the latter contains blende, showing crystalline faces, disseminated through it; also bitumen, diffused in specks. Analysis 382 of the table on p. 447, is of this chert.

The ore does not follow a crevice, nor does it occur in a run, but is found in bunches in the dolomized rock, and also following decomposed and altered layers between the limestone strata. The blende is of a very brilliant ruby-red and cinnamon color; no steel blende was noticed. As the statistics show, galena is present in large quantities, but is not so abundant as blende. No silicates or carbonates were observed; in some shafts marcasite is found.

The presence of limestone, only partially decomposed, seems to characterize much of the ground of this tract, as do also the great dolomitization and the abundance of calcite crystals. As can be seen on the map, these mines are located about on the crest of the divide between Shoal creek and Turkey creek. No map of this mine could be obtained, nor of any on this tract excepting of the small opening illustrated in the following cut.

As showing the character of the ground here, the record of a drill-hole put down in SW. of SE quarter of section 11 is illustrated by figure 96, on page 410.

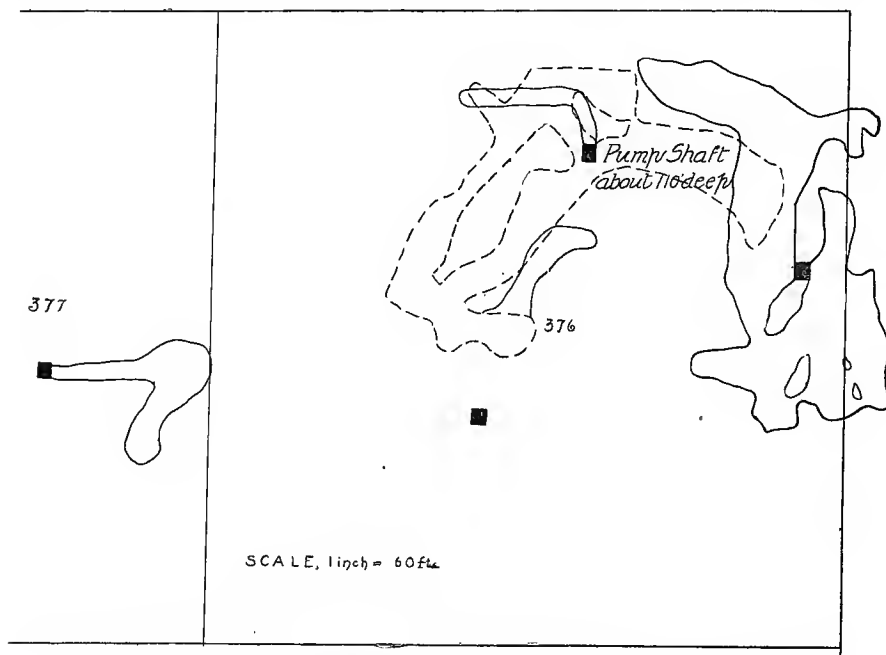


FIG. 123. Map of Cook, Middlebury & Co.'s mine, Western Zinc Co.'s land.
From map furnished by J. R. Holibaugh, M. E.

These lands were the scene of active mining years ago, and Schmidt, in his report of 1873, describes a number of mines here. Among these were *Cox and Pierce* and the *Thomas diggings*, located in the SE. of the SW. quarter of section 12. Shafts as deep as 100 ft. were sunk, and encountered clay and a conglomerate, consisting of boulders of limestone containing seams and crystals of galena, in tallow clay and yellow sand, partly cemented by calamine; masses of blende were found lower down with broken chert and clay. In one shaft, a band of black shale, 3 ft. thick, was found standing vertically in the breccia. This was followed down 22 ft.

In the *Schott diggings*, about the middle of the east line of section 11, black, Coal Measure shale was also struck beneath the soil.

The *Jasper diggings*, in the SE. of the NE. quarter of section 11, Schmidt describes as being in broken chert, containing galena and calamine, underlain by layers of limestone and chert, containing large openings filled with red clay; these layers were disturbed and broken, and galena and blende were found both in the clay and in the associated limestone and chert. Decomposed dolomite was also found, though, in places, it was in a fresh condition, alternating with bands of dolomitic limestone. The blende was found mostly in irregular streaks and pockets in the dolomitic rocks, while the galena existed in horizontal seams, 2 to 5 ins. thick, 3 to 5 ft. wide and 40 to 60 ft. long; these seams were separated by from one to two feet of rotten dolomite.

In the *Short and Temple diggings* of the adjoining quarter to the north, the ore ground was similar; the chert breccia was cemented by gray quartzite; rose-colored dolomite was found, soft, sandy and bituminous, and containing galena and blende in streaks and masses.

The well-known *Swindle Hill diggings* were in the N. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 11. The ore body consisted, apparently, of brecciated chert, with occasional blocks of limestone; around these fragments was dolomite of white, rose and black colors; in this, both galena and blende were found. The ore followed certain runs which were parallel to each other. Much bitumen was associated with the ore; in some shafts, black shale, as much as 20 ft thick, was encountered. The adjoining figure, reproduced from Schmidt's report, illustrates his conception of the conditions of occurrence here. According to his statement, it was plainly seen here that the "runs were formerly vertical clefts in the limestone boulders."

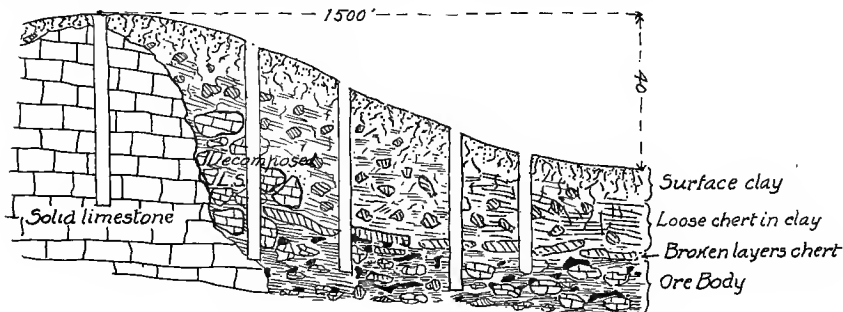


FIG. 124. Section at Swindle hill diggings.
From A. Schmidt, Report 1873-74.

THE THOUSAND-ACRE TRACT OF MEX M. & S. CO.

This tract nearly adjoins that of the Western Zinc company on the east. As its name denotes, it covers 1000 acres of land, including all of section 18 and the south half of section 7, and the NW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 8, township 27 N. 32 W. Prospecting was not begun on this tract until April, 1891, and active developments did not follow until the spring of 1892; but after this, the mines rapidly assumed a place among the largest producers of the camp. The tract is divided into 40-acre lots, which are leased out to mining companies. At the close of 1893, according to notes furnished by Mr. J. R. Holibaugh, there were 10 large companies and not less than 60 small companies operating; five large concentrating plants were at work, each having a capacity of from 50 to 75 tons per day. The following figures will convey an idea of the magnitude of the productions from these mines:

	Lead ore.		Zinc ore.	
	Tons.	Receipts.	Tons.	Receipts.
May 14, 1892, to December 31, 1892 a.....	810	.....	5,130	.....
1893 a	975	\$35,015	9,307	\$185,779

a From J. R. Holibaugh, obtained from the company's books.

The royalty paid is generally about 10 per cent, though sometimes more.

Among the important mines of this tract are those of the Crossman mining company and of the World's Fair company, the Porter, Stillwell and the American mining companies. A few of these we will now proceed to describe:

The World's Fair Mining Co.—The lands of this company include the N. $\frac{1}{2}$ of the NW. of the SW. $\frac{1}{4}$ of section 7. They are situated on the crest of the divide between Shoal and Turkey creeks, and are about 100 ft. above Turkey creek; this is well shown on the topographic maps of the Survey. Comparatively little work had been done here at the time of inspection, and this was mainly of an exploratory character. The Hood shaft was examined, and showed many facts of interest. The total depth was 106 ft., and a short drift was started at 75 ft. The following section of the shaft (Fig. 125) is from notes kindly furnished by Mr. Hood, taken while sinking the shaft:

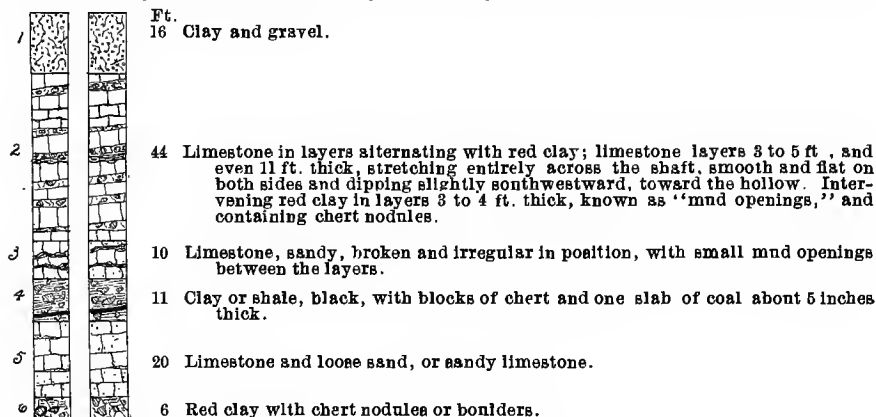


FIG. 125. Section of Hood shaft.

The drift was started in No. 4 of the above section. Large, crystallized masses of marcasite were found, but little or no zinc or lead was observed. The occurrence of coal under beds of limestone is quite peculiar; it must have been introduced from elsewhere, and is not in its original position. Only 50 feet northwest of this is another shaft 26 feet deep, the lower 3 feet of which is compact, dark gray, Lower Carboniferous limestone.

The Crossman mines.—These mines are less than half a mile southwest of the last, in the southeastern corner of the same quarter-section. Like the last, they are located in the prairie on the crest of the divide. This is one of a group of mines on this tract which has been remarkably productive, the ore being exceptionally easily won. Shaft No. 1, when visited, was 85 feet deep, and a drift was driven at 62 feet.

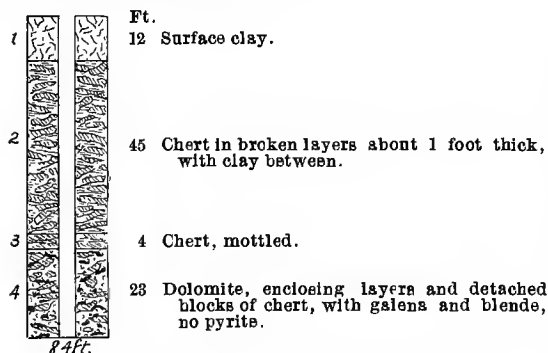


FIG. 126. Section of the Crossman M. Co. Shaft No. 1.

Fig. 126, obtained from personal observation and from information furnished by the mine foreman, illustrates the conditions here.

No. 4 is well exposed in the drift in a northeasterly direction from the shaft; limestone bars were encountered in this drift, of a dark-gray color and crystalline texture, about 50 ft. west of the shaft. The breccia, or ore body, does not grade into limestone, but exhibits a sharp contact along the pillars and bars. The distribution of the drifts and the shape of the ore body is well shown in the opposite map.

The Sharpe lease is another important development, in the NW. of the NE. $\frac{1}{4}$ of section 18. This mine was not examined, but, according to information furnished by Mr. Sharpe, the ore body consists of the usual chert breccia. The peculiarity of this deposit is that considerable quantities of plastic, white sulphide of zinc are found in the clay surrounding the chert fragments; it has blende crystals imbedded in it. This lease has been very productive, yielding, according to Mr. Sharpe's statement, during the year ending July, 1893, 250 tons of lead ore and 2000 tons of zinc ore from less than one acre of excavation; this was further only down to a depth of 87 feet, above which there was 45 feet of ore; below this, 37 feet of ore yet remained, so far as prospected. Maps of the workings are shown in figure 128.

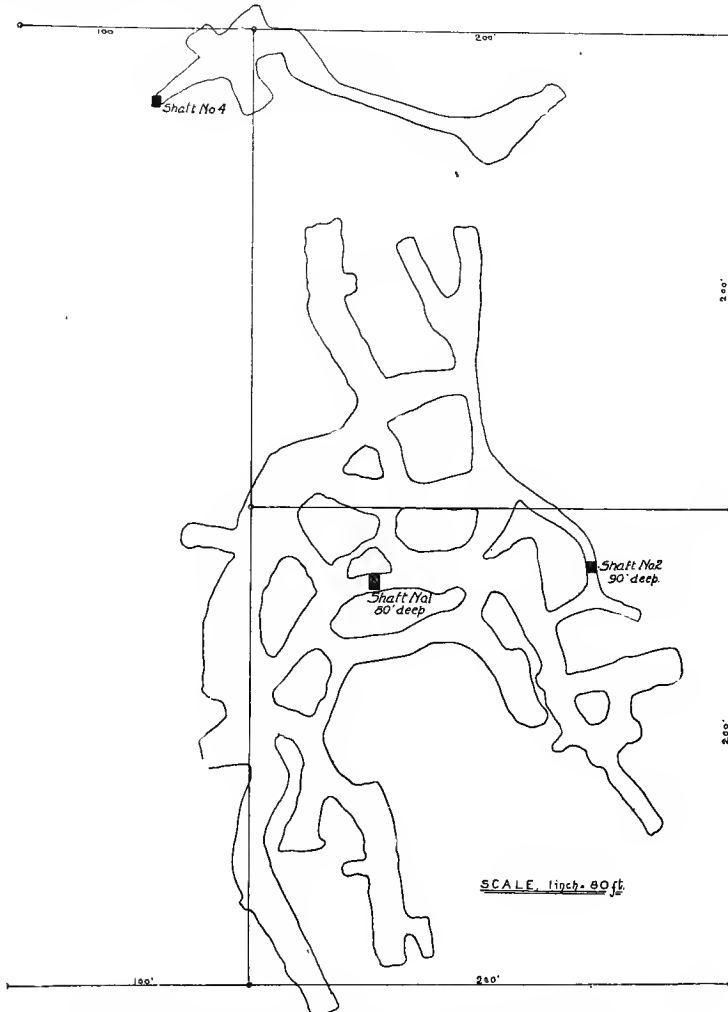


FIG. 127. Map of the Crossman mine on the Thousand-acre tract.
From surveys by S. J. McKee, C. E.

North of the Thousand-acre tract, between it and Turkey creek, are a number of other developments, some of which have produced large quantities of ore during past years. These include the mines of the Arkansas Mining company, C. H. Jackson Mining company, Jacobs Brothers (production 1891, '92 and '93, 1082 tons lead ore, 206 tons zinc ore=\$46 800), Pearl Mining company, Superior Lead and Zinc company, and the Great Western Zinc and Lead company.

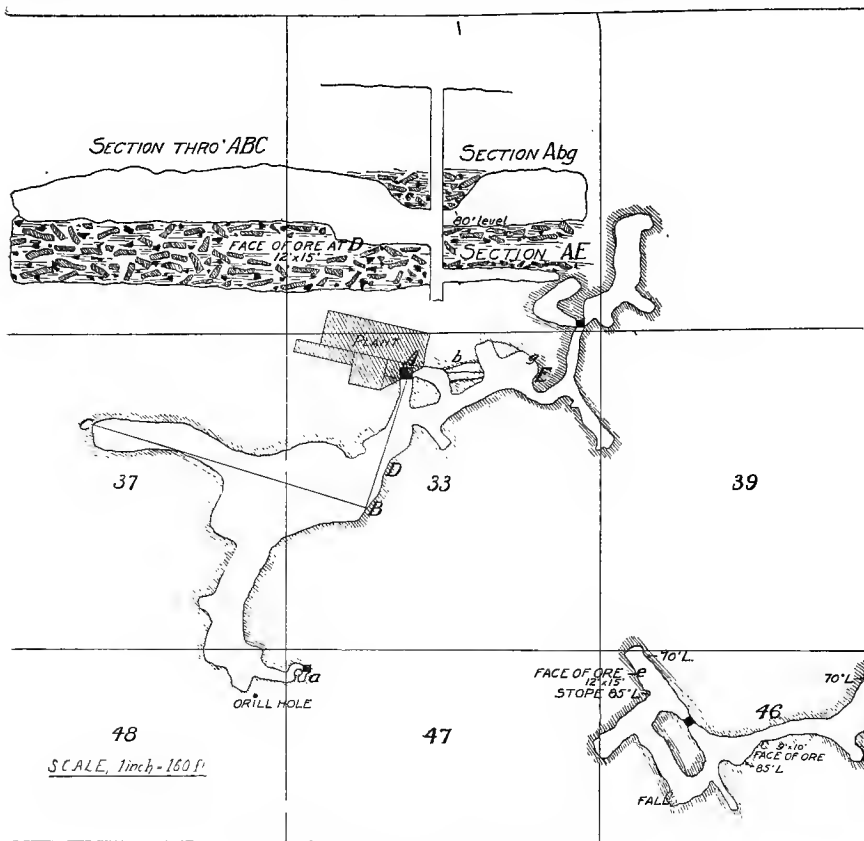


FIG. 128. Map of the Sharpe mine, on the Thousand-acre tract.

Furnished by J. R. Holibaugh.

THE WINDSOR MINING COMPANY.

The mines of this company are situated in the south half of the SW. $\frac{1}{4}$ of section 1, township 27 N., 33 W., and are thus just north of the Western Zinc company's lands. They are located in the prairie on the summit of the divide above Turkey creek. A number of shafts have been put down here, and quite large operations were conducted. The following figures give some idea of the productivity:

	Lead ore.		Zinc ore.	
	Tons	Values.	Tons	Values.
1891a	190	\$8,740	1,090	\$26,260
1892a	461	21,667	1,087	23,851

a Report State Mine Inspector; year ending June 30.

The Hamilton shaft, situated near the southeastern corner of the tract, was examined. The shaft is 110 ft. deep. Drifts are run at two different levels, the upper one being at 85 ft. The roof, immediately over this drift, is of bedded chert, occurring in thin layers or slabs. Under this is a large body of dark-gray dolomite, at one place as much as 25 ft. thick; it is very soft, and can be excavated with a pick; blende was disseminated through it. Elsewhere, tallow clay and black shale or clay-surrounded slabs and blocks of chert were found, the ore being disseminated through the matrix. The ore occurring in the breccia is principally blende, frequently well crystallized; some galena is also found.

Immediately north of the Windsor lands are the lands of the Cora Lotta Mining company. They are in similar ground, but are of comparatively recent development, and had produced only a few hundred tons of ore to date.

THE PORTER LANDS AND VICINITY.

Immediately west of the Windsor lands are the lands of the Granby Mining and Smelting company; beyond this is the Cook forty, and beyond this again to the west are the Porter mines, occupying the southern half of the SW. $\frac{1}{4}$ of section 2. This last tract of land, though now largely built over, was formerly very productive ground. Diggings here were described by Schmidt in 1873, when there were numerous shafts from 6 to 40 ft. deep. Galena was found in runs in broken chert, accompanied by some blocks of limestone; ore-bearing, dolomitic limestone also was found, mixed with chert and containing some bitumen; in this, galena and blende occurred in pockets; in some of the shafts, black shale or clay was found.

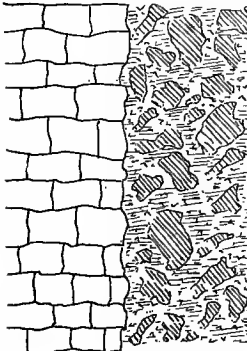


FIG. 129. Section at the Keith shaft. (Broadhead.)

The Orchard diggings were immediately north of this, on the east side of Joplin creek, near the center of the section. Here the ground seems to have been very irregular; a number of shallow shafts were sunk, and a good deal of black shale was found; also masses of broken chert, which were frequently soft and porous and contained bitumen; galena was found in small crystals, and some calcite; streaks of dolomite occurred in the limestone.

Broadhead, in describing Jasper county in the report of 1873, refers to the mines along Joplin creek on page 90. He notices the absence of solid beds of limestone, and the presence of loose chert and dolomite in their place, through which the lead is irregularly distributed. He gives an illustration of the conditions in the Keith shaft, on the Porter land, which we reproduce here. He refers to pockets of coal being found just west of Joplin, of irregular form and thinning out rapidly.

THE CONSOLIDATED MINING COMPANY'S LANDS AND VICINITY.

Covering the west half of the NW. $\frac{1}{4}$ of section 2, as well as the forty acres north of this, in the next section, are the lands of the Consolidated Mining company. They have not been very actively worked during recent years, but, over this and adjoining tracts, much mining was done during the early seventies.

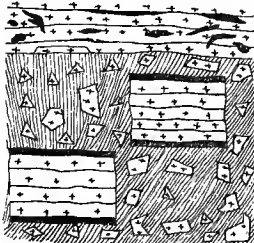


FIG. 130. Section at the Consolidated M. Co.'s land. (Schmidt)

The Moon diggings, described by Schmidt, were in and adjacent to the southeastern corner of this company's land. The ground here was greatly disturbed, and the dolomite was mostly very soft and rotten; in some of the shafts the ore was found in regular runs at two levels; in these the blende occurred diffused and associated with galena; there was much pyrite cementing the chert and galena; no bitumen was found. The structure of the ore body is illustrated in the adjoining cut taken from Schmidt's report. The large broken fragments of chert, with galena attached, indicate brecciation after the deposition of the galena, as pointed out by Schmidt.

LEAD AND ZINC DEPOSITS OF MISSOURI.

The East Joplin diggings closely adjoined the Moon diggings, and are described by Schmidt as consisting of shafts in broken chert and yellow and brown clay, underlain by blocks of soft limestone, dolomized on the outside; between these was sandy dolomite or clay, containing chunks and streaks of galena; blende and pyrite were occasionally found.

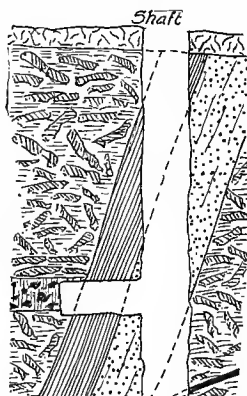


FIG. 131. Section at the Woodson shaft. (Schmidt)

The Four Corner diggings, described by Schmidt, were adjacent to the middle of the west line of the NW. $\frac{1}{4}$ of section 2, and hence were on the western edge of the Consolidated Mining company's tract. In the Woodson shaft here, as illustrated in figure 131 after Schmidt, a bed of sandstone, overlain by black slate, was encountered. It occupied a nearly vertical position, and a breccia of broken chert and dolomite, with galena and blende, was found on both sides; this slate and sandstone were doubtless of Coxi Measur age.

Murphysburg diggings were about a quarter of a mile south of this group; the shafts there were 70 to 80 ft. deep, through soil and broken chert and limestone, underlain by a breccia of chert fragments cemented by gray quartzite; at a depth of 80 ft. boulders of soft limestone were found, with dolomite enclosing crystals of galena.

The McCrum diggings ought also to be mentioned here. They consisted of a number of shafts in a straight line running SE. to NW. These shafts were sunk in an enormous accumulation of broken chert and a few limestone blocks. Through this, Schmidt describes what he calls a fissure, running in the direction indicated by the shafts. He recognizes it as very irregular, however, with ill-defined walls, often splitting up and branching in all directions, and filled with a finely broken, loose chert, containing much galena.

The lands of the North Joplin Mining company and of the New York Mining company are in the SE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 34, township 28N., 33W., farther down Joplin creek. A few hundred tons of ore have been produced from these lands during the last few years. In the past, the Joplin Valley diggings were in this vicinity, many of which were in the creek bottom and were quite shallow; they worked largely in loose, red clay; some shafts penetrated to depths of 30 or 70 ft., and encountered broken chert with dolomitic sands and clay; in some diggings runs of ore 5 to 12 ft. in diameter and 20 to 80 ft. long were encountered. Patches of black, micaceous shale were sometimes found at shallow depths, between the soil and the chert breccia. Galena occurs in loose pieces, or in sheets as much as 6 ins. thick, sometimes mixed with blende; crystals attached to the surfaces of the chert fragments indicate that there has been no brecciating movement since their deposition.

THE GRANBY MINING AND SMELTING COMPANY.

The lands of this company extend west from the last for over a mile and a half, covering almost all of the southern half of sections 33 and 34, and part of the northern half of these sections which lie south of Turkey creek. They thus include the formerly well-known Lone Elm diggings, as well as those in Leadville and Possum hollows and Poor Man's gulch. The following table of productions indicates the extent of the outputs of these mines near Joplin:

	Lead ore.		Zinc ore.	
	Tons	Values.	Tons	Values.
1873a	1,038	.....	.....	.....
1886b	.....	.....	480	\$9,120
1890c	526	\$23,710	884	23,189
1891c	211	9,073	2,091	48,098
1892c	407	17,974	4,986	116,228
1893c	247	9,529	3,798	84,681

a Lloyd and Bauman [142]. b Jno. N. Wilson [242]. c State Mine Inspector reports, years ending June 30.

The property is sub-leased to different individuals and companies in lots of various sizes, and, though much work on a small scale has been done, many large operations are also included.

The Baker Shaft in Possum Hollow—This mine is located in the extreme northeastern corner of the camp, in the midst of a number of mines which have produced large quantities of ore.

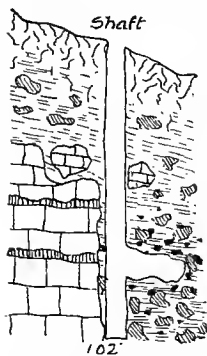


FIG. 132 Section at Baker shaft, Possum Hol.

It was somewhere near this locality that the old *Mineral Point* or *Shake Rag* diggings, described by Swallow in 1854, were located; here, in Harklerode's pits, Swallow speaks of two lodes or sheets of mineral lying nearly horizontal in the Carboniferous limestone. At Frazier and Cavenar's pits, he describes a horizontal fissure in a conglomerate of chert, filled with galena and clay.

Lone Elm Hollow.—The old Lone Elm diggings were on both sides of Lone Elm creek, in the NW. $\frac{1}{4}$ of section 3, township 27 N., 33 W., and in the SW. $\frac{1}{4}$ of section 34, township 28 N., 33 W.; they thus occupied the land on which the Picher lead-works are now located, and the country north of it.

Little or no work has been done over this area during recent years. For descriptions of the deposits, we are hence dependent upon Schmidt's report for 1873. He describes a number of different shafts. The *Morse shaft*, which was located a little north of the center of section 3, was about 50 ft. deep and penetrated, first, a yellow clay and some chert and loose galena for 30 ft., then 10 ft. of soft bituminous limestone with some galena, and, finally, 10 ft. of broken chert layers, 3 to 4 ins. thick, with a little limestone. In the *Sutton shaft* adjoining, similar material was passed through, and, in addition, layers of black, bituminous clay were found. In the *Harrington shaft*, also close by, coal and slate were encountered, dipping strongly to the north, and cutting off the layers of ore and the surrounding breccia. In the *Hayes shaft*, near the middle of the south line of section 34, broken chert with clay and loose galena overlying layers of chert and blocks of limestone, were encountered, the limestone being very bituminous. In the *Acton shaft*, a few hundred feet farther north, ore was found in broken chert and dolomitic limestone. The *Slatton* and other shafts adjoining the last to the east, were in masses of chert, which were penetrated by cracks and cavities, filled with red or black clay and lumps of galena. The ore bodies of other shafts are described as occurring in runs down to a depth of 70 ft., the runs being 3 to 4 ft. high and 3 to 10 ft. wide, in clay and broken chert, surrounded by dolomite. In one shaft chert breccia was encountered, cemented by "quartzite," containing blende and dolomite crystals; small quartz crystals were also found here lining the cavities. Schmidt notes the occurrence of bluffs in Lone Elm hollow exposing masses of chert breccia, like that found in many shafts; also several bluffs exposing undisturbed layers of limestone, with concretions and thin layers of chert.

Leadville Hollow.—In Leadville hollow, along the western half of section 33, Schmidt describes a number of diggings. In *Pound's shaft*, a little south of the southwestern corner of section 33, the contact between undisturbed layers of limestone and chert on the one side, and brecciated chert on the other, was followed down 62 ft. Other shafts north of this passed through layers of limestone and chert with bitumen, the soft limestone containing galena and blende. Several shafts were in brecciated chert, overlying decomposed limestone blocks.

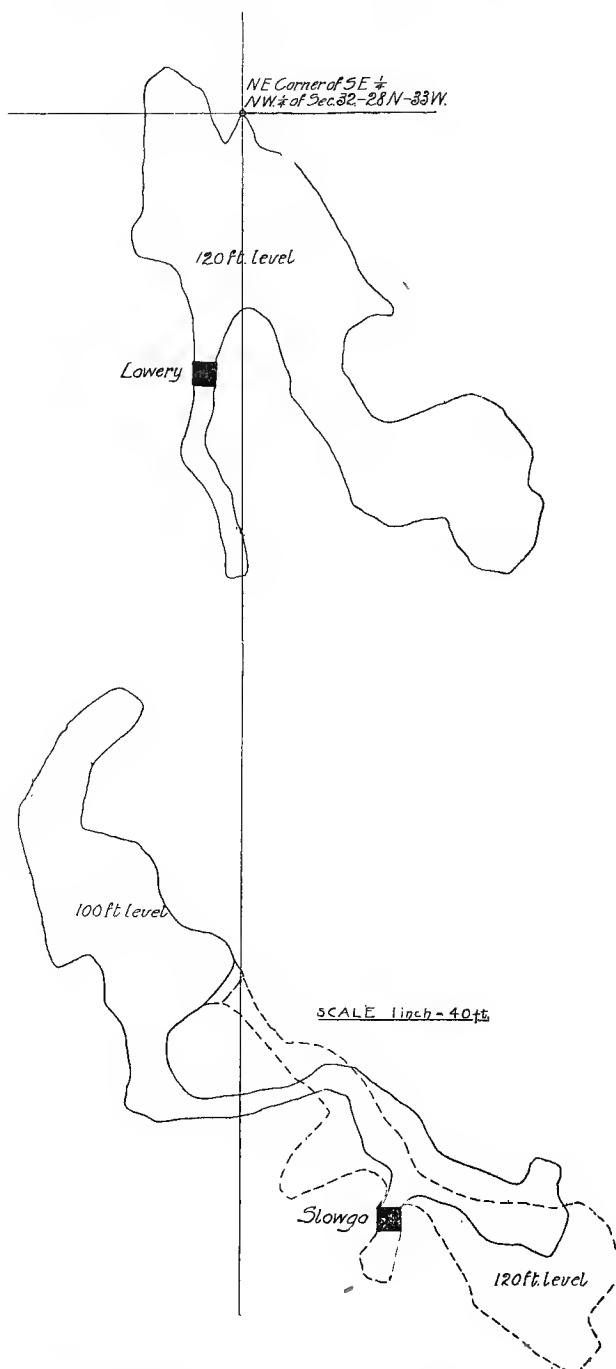


FIG. 134. Map of the Slowgo and Lowery mines. Furnished by J. R. Holthaugh, M. E.

In the *Horse Shoe Diggings*, the shafts were arranged in a semi-circle, in the shape of a horse-shoe, and were in the usual brecciated ore; some shafts near the middle of these diggings passed through thin beds of black, micaceous shale. Near this, bluffs of undisturbed white chert and fine-grained limestone were found.

Broadhead briefly refers to mines here on page 89 of his report of 1873. He speaks of work having been done along this creek as early as 1851. In the old *Taylor or Orchard mines*, he describes a shaft 70 feet deep, at the bottom of which solid limestone with lenticular beds of chert were encountered, in which the galena and zinc were found in horizontal sheets, as illustrated in the adjoining figure.

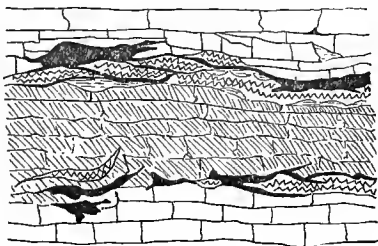


FIG. 133. Section at the Taylor diggings. (Broadhead.)

Leadville hollow has continued the scene of more or less mining since the beginning up to the present time, latterly especially in the northern part. Here are mines of the Semino Mining company and of Barrett & Company. Opportunity was not afforded to visit these mines, but the ground is similar to that of the surrounding ore bodies.

The opposite map shows the extent and shape of the deposits in two of these openings.

THE TUCKAHOE MINES.

This group of mines is situated north of Turkey creek, principally in the SW. $\frac{1}{4}$ of section 27, and in the E. $\frac{1}{4}$ of section 28, on the hill slopes of a small tributary of the creek. This has been the scene of large operations in recent years, and great quantities of ore have been mined. The most important companies are the Tuckahoe Mining company, the Sterling Lead and Zinc company, Byers, Murphy & Connor, and the Turkey Creek Mining company. An idea of the production of the mines of this group may be gathered from the following table:

	Lead ores.		Zinc ores.	
	Tons.	Value.	Tons.	Value.
{ Tuckahoe M. Co., 1890 to '92 (a)	437	\$22,873	1,746	\$42,598
{ Globe Zinc Co., 1886 (b)			601	12,020
Sterling L. & Z. Co., 1890 to '92 (a)	188	8,429	4,492	113,101
Byers, Murphy & Co., { 1886 (b)			555	11,347
{ 1891 and '92 (a)	3	117	512	12,772
Turkey Cr. M. Co., { 1886 (b)	98	4,770	2,575	50,251
{ 1891 to '93 (a)	159	7,397	4,207	96,791
Jasper M. Co., Montgomery land, 1886 (b)			604	11,506

(a) From the State Mine Inspector's report, years ending June 30.

(b) From Jno. H. Wilson [242].

At the time this locality was visited very few shafts were being operated, and only one was inspected. We have been so fortunate, however, as to obtain copies of a number of underground maps, which are shown in a reduced form on next page.

Henry Tucker shaft, in the NW. corner of section 34, on the Jasper Mining company's land, was examined. It is located in Turkey creek valley. It was 177 feet deep, and below this a drill hole had been put down to a depth of 250 feet. At 105 feet a short drift was driven to the east.

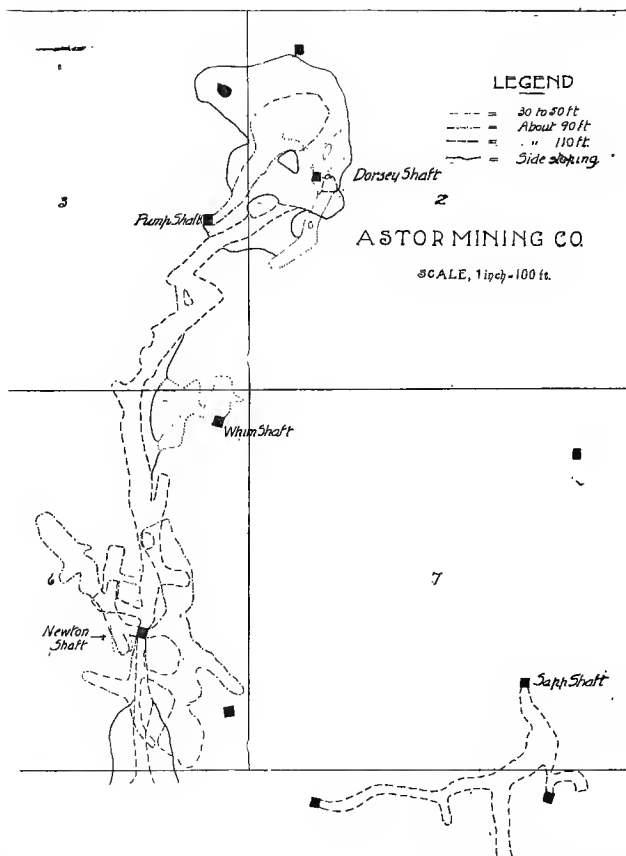
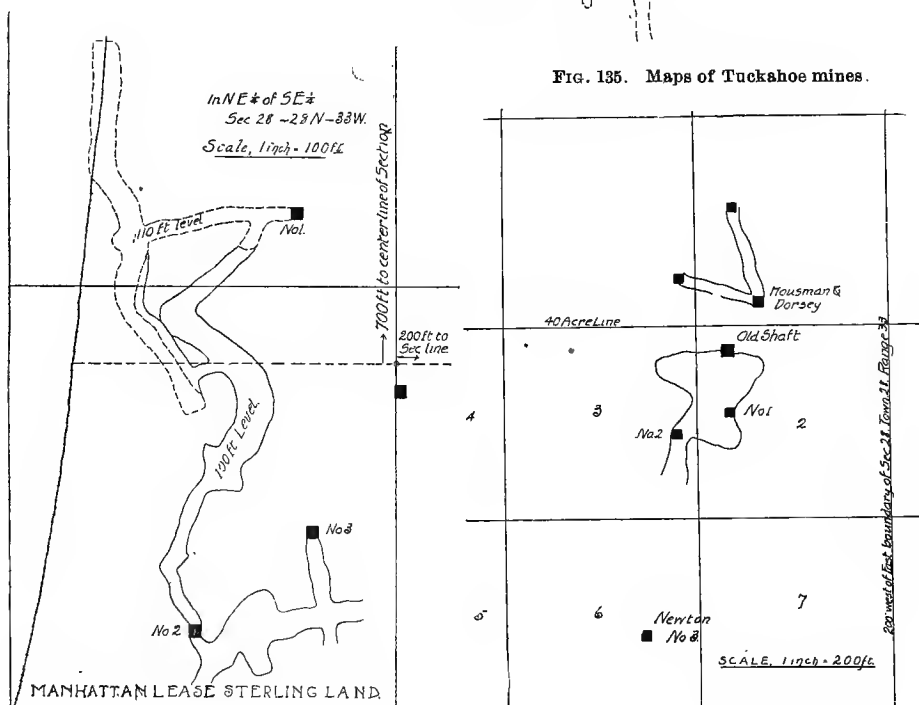


FIG. 135. Maps of Tuckshoe mines.



From notes given by Mr Tucher, and from an inspection of the drill cuttings, the record given in figure 93 of page 408 was prepared.

The drift was driven in the white chert and decomposed limestone (No. 3 of the section), but showed only a small amount of galena in the breccia. The white chert is very much mottled, and is also often soft and decomposed. A special chemical and microscopic examination was made of this chert, the results of which are given in Appendix A (Anal. No. 376) of this report. A map of the workings in a closely adjoining lot of ground is placed on record in the adjoining illustration

Leaving these outlying mines north of the Jasper camp, we will return to those of the southwestern portion.

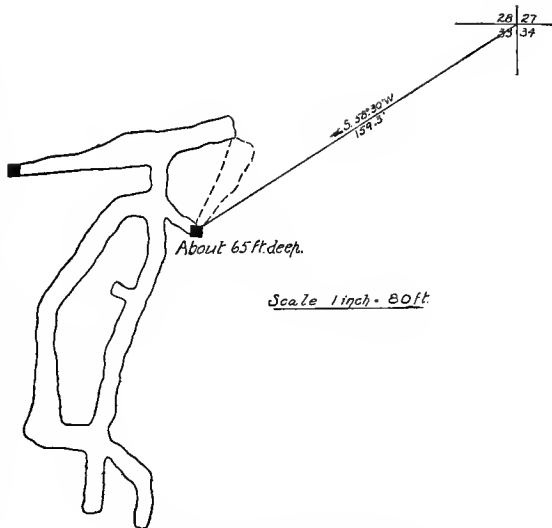


FIG. 136. Map of the Big Run mine.
From surveys of S. J. McKee, C. E.

THE KOHLNOOR MINES.

The Kohlnoor mines, belonging to the Empire Zinc company, consist of several shafts located about the southeastern corner of section 4, in a prairie, near the divide between Turkey and Shoal creeks. They are close to the zinc-smelting works belonging to the same company. This land was owned by Byers, Conner & Murphy before it was taken hold of by the Empire company in 1889; since that time it has produced as follows, according to the company's books:

	Lead ore.	Zinc ore.		Lead ore.	Zinc ore.
	Tons			Tons.	
1890.....	No lead ore	401	1892	1	1,720
1891.....	" "	1,266	1893.....	1	2,278

The figures of page 566, reproduced from the excellent mine maps of the company, show the location and the extent of the workings; they also show very clearly the nature of the ground traversed and the depths of the drifts, and are, hence, more instructive than any other of the maps presented.

Shaft No. 5 was examined by the writer. It was about 140 ft. deep, and drifts were driven from it at several levels; the lowermost one was examined. As is shown on the map, the run of ore here follows a NE.-SW. direction. The ore bodies consist largely of a black secondary chert, and some dolomite, associated with dolomite of a later formation, and a dark tallow clay. An analysis (No. 397) of this clay was made and the results are given on page 445. Limestone bars or walls were encountered at a number of points. Some of the chert gangue is also decidedly calcareous, and there has been undoubtedly a secondary deposition of lime in the matrix, producing sometimes a rock closely resembling the limestone country rock. No galena is found in this lower run, the yield being entirely blende. The runs of ore and the overlying chert beds dip a little to the southwest under the hill. An upper drift was worked from this shaft in the past years at a depth of 70 ft.; the ore run here had a course NW.-SE., and was underlain by a heavy bed of chert. The ore body, as described by the foreman, consisted of a breccia of chert and limestone, containing both blende and galena; bitumen was also quite abundant in the ore.

In Shaft No. 2, as indicated by the map, the ore body seems to have something of the cone shape of the Coon mines described on page 552.

are often distinguishable. The entire absence of anything like stalactites is noticeable, and, together with the presence of the crystals, shows that the cave was completely filled with water during their growth. It is only with the extension of mining in this vicinity to greater depths that the water level has been lowered.

THE SOUTH JOPLIN MINING COMPANY.

About half a mile southeast of the Kohnoor mines is the South Joplin Mining Co.'s mine.

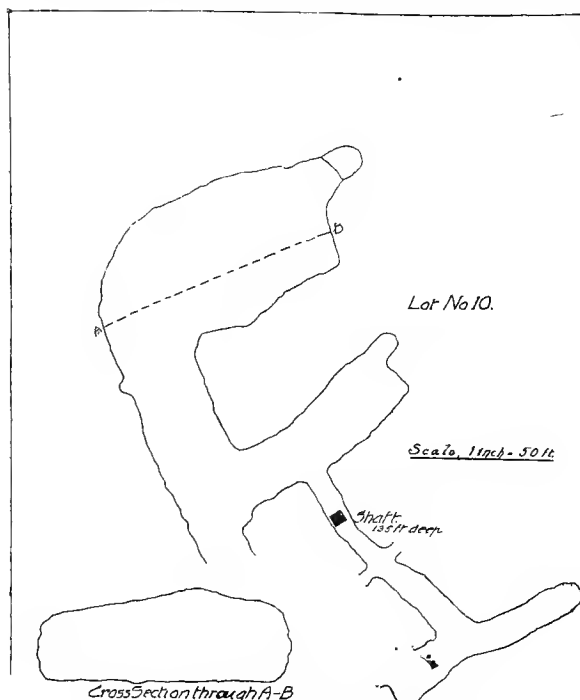


FIG. 139. Map of South Joplin Mining Co.'s mine.
From surveys by S. J. McKee, C. E.

tions of these mines during the recent years. The productions, though large, are not up to those of the most prominent mines.

PRODUCTIONS OF THE ROARING SPRINGS M. CO.

From J. R. Holibaugh, from a statement of the company.

		Lead ore.		Zinc ore.				Lead ore.		Zinc ore.	
		Tons.	Values.	Tons.	Values.			Tons.	Values.	Tons.	Values.
1889.....				344	\$6,536	1892.....		86	\$3,447	1,117	\$17,888
1890.....				318	6,094	1893.....		36	1,294	527	8,445
1891.....	7	\$393		977	15,632	Total.....		129	5,134	3,283	54,595

ORE SOLD FROM THE SCOTIA MINE.

From J. R. Holibaugh, as furnished by H. H. Gregg.

		Zinc ore.				Zinc ore.	
		Tons	Values.			Tons.	Values.
1891.....		75	\$1,783	1893.....		745	\$12,451
1892.....		1,087	24,943	Total.....		1,907	39,177

Zinc ore is exclusively mined, the production for the three years, 1890 to 1892, being nearly 3000 tons of zinc ore and only a ton or two of lead ore. It is comparatively a recent development, and was not examined by the Survey. The accompanying plat shows the shape and extent of the workings.

From these descriptions of the deposits within the exact limits of the camp, we will proceed to, and conclude with a description of the outlying Roaring Springs group.

THE ROARING SPRINGS GROUP.

The mines of this group, some four miles southwest of Joplin, are clustered about the common corner of sections 17, 18, 19 and 20, of township 27 N., 33 W., as is illustrated in the map of the next page. The principal diggings are on the lands of the Roaring Springs Land & Mining company, the Scotia Mining company and P. Murphy and Byers. The following tables give the produc-

These mines have been operated for several years, much ground has been worked over and many interesting occurrences of ore have been revealed.

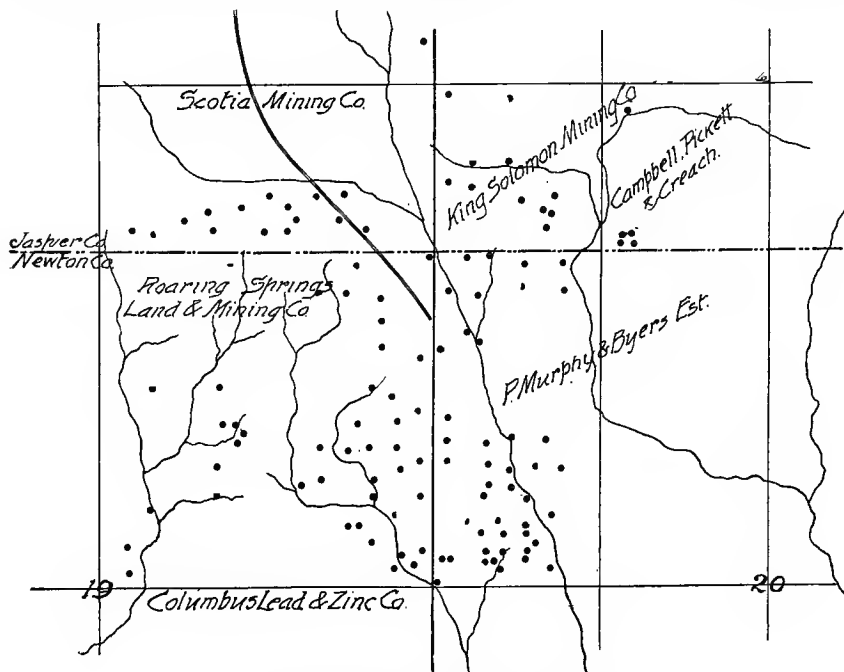


FIG. 140. Map of Roaring Springs group.
From map of J. R. Holibaugh, M. E.

The Roaring Springs Land and Mining company's mines are described as follows by Mr. Robertson:

"Most of the mining here is done by individuals to whom the land is leased. There are some ten or more producing shafts, all of which are sunk in the limestone which prevails over this portion of the county. At an average depth of 60 feet the heavy bedded cherts are struck, and are here considered bed-rock, no attempt having been made to penetrate them.

"The ore consists mainly of blende, of good quality and quite light in color, some being a bright yellow. It is rarely crystallized, and is found in the broken chert cemented together by a secondary chert of a dark drab color. A variety of blende known as "steel jack," on account of its peculiar steel-like color and luster, is found and is considered of a very good quality. Galena also occurs here, and forms an item in ore shipments.

"The ore body seems to be a large run with a direction N. 40° W. It has been followed by drifting for several hundred feet from the different shafts; the width and thickness are very variable.

"Blende and galena are the principal minerals. Pyrite occurs to a limited extent, as does marcasite also; very little calcite was noticed."

Lee, Roberts & Alleyer's shaft, on this company's property, was examined by the writer. The shaft was about 50 ft. deep. The ore was disseminated through a chert breccia, the fragments of which were detached, not in layers; the matrix consisted in part of a dark, hard, impure secondary chert; a good deal of pyrite was mixed with the ore. Over the ore body was a mass of fractured white chert. A specimen of chert found here was distinctly sickle-shaped, and what is of chief interest, small crystals of transparent, reddish blende were attached to this surface, showing that the blende had been deposited since the movement took place.

The Gregg shaft, on the Scotia Mining company's land, near the southeastern corner of section 18, was also examined by the writer. Two shafts were sunk on each side of a small ravine, along

which croppings of white chert were abundant. The main shaft on the south side was about 52 ft. deep at the time of visit, and drifts ran north and south from this. The ore occurred between lenticular layers of chert, which, in places, were very little disturbed, as is illustrated in the adjoining figure. The ore consisted almost entirely of blende of black and rosin colors; also some steel blende; very little or no galena was seen, and no pyrites. These minerals were bedded in a red dirt or clay, or in earthy dark matrix, somewhat silicified, which filled the spaces between the chert slabs. On the north side of the shaft, such ore-bearing chert was exposed to a height of 10 or 12 ft. above the bottom of the drift, while its depth below was undetermined. At several points a continuous bed of hard flint was struck in the roof, and the bulk of the red dirt and clay was found immediately under this. Toward the south the roof rock dipped under the hill, and the ore-bearing chert was more compact and showed less ore.



FIG. 141. Ore body in the Gregg shaft.

THE BELLEVILLE CAMP.

The town of Belleville and the included mines are on the north side of Turkey creek, about the middle of section 25, township 28 N., 34 W.; the camp, however, as here defined, includes also the mines of West hollow, East hollow and Cottonwood hollow, on the south side of the creek. The mines about the town of Belleville have been very productive, and the excavations in some are very extensive; these include the mines of the Standard Zinc and Lead company, the Knoble M. company, the Hoff L. and M. company, the Pat Murphy land, and the Rosemond M. company. The size of these mines may be judged of from the following table of production, for the years 1891 and 1892 (ending June 30), as given by the State Mine Inspector :

	Lead ore.	Zinc ore.		Lead ore.	Zinc ore.
	Tons.	Tons.		Tons.	Tons.
Standard L. and Z. Co		3057	Pat Murphy land	46	617
Knoble M. Co	24	1869	S. A. Holden (1890)	65	1659
Hoff M. Co	9	214			

A large part of the production, however, was, during years before 1890, as is shown in the following statement of productions at Belleville for 1886, extracted from Mr. Jno. N. Wilson's tables :

	Lead ore.		Zinc ore.	
	Tons.	Value.	Tons.	Value.
Pat Murphy	75	\$3,600	4,350	\$93,626
G. W. Bruce	2	63	1,850	36,950
S. B. Holden	47	2,340	1,909	41,050
North Belleville L. & Z. Co.	32	1,584	950	18,999
Frye & Sons			102	2,188

From May 1, 1886, to June 1, 1889, the sales of zinc and lead ores from the Holden mines yielded \$117,745, according to J. R. Holibaugh. As the tables plainly show, the production of lead is insignificant as compared with the zinc.

The mines are here clustered close about the town, and the character of the ore bodies probably does not differ very much. Time permitted the examination of only one mine, which we will now describe as a type of the group.

THE STANDARD ZINC AND LEAD COMPANY.

The shafts of this company are located in the N. $\frac{1}{2}$ of the NE. $\frac{1}{4}$ of section 25, on the hill-slopes north of Turkey creek, and probably less than 100 ft. above the valley. This is one of the largest mines of the group, and the extent of the workings is shown on the following map:

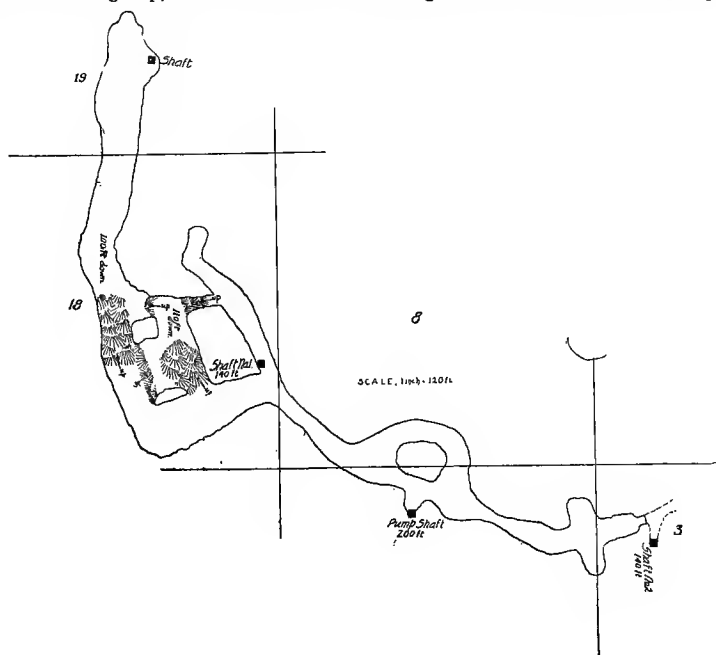


FIG. 142. Map of the Standard mine.

From surveys of J. R. Holibaugh.

The productions of recent years are as follows:

1887.....	1,106 tons zinc ore sold for.....	\$32,850
1888.....	1,479 " " "	29,588
1889.....	1,766 " " "	40,218
1890.....	1,388 " " "	34,918
1891.....	1,715 " " "	40,595

From 30 acres on the east, leased by the company, 4978 tons of zinc ore were mined during the same period. These figures were all obtained from the books by Mr. Holibaugh.

At the time of inspection the bottom of the shaft was about 150 feet below the surface, but we are informed that since that time it has been sunk 50 feet deeper, in chert. The drift was at the 150-foot level, and the excavation was very large and high, reaching as much as 70 feet or more in some places. The gangue was hard, consisting of a black, impure, secondary chert, cementing fragments of the original white chert; clay or shale was also sometimes found in this breccia; the matrix is often calcareous to the extent of being a crystalline limestone. This ore body or breccia lies between walls or "bars" of limestone which are encountered in drifts. In No. 2 shaft, shown on the map, a limestone bed was struck at a depth of only 40 or 50 feet, which proved to be about 10 feet thick; under this the ore breccia was found. The principal metalliferous constituent is blende,

which is found in the siliceous matrix of the breccia, and bedded in clay in the spaces between the chert fragments; almost no galena is found; some pyrite occurs, and was seen to be deposited on blende in places; a little dolomite was observed, and calcite crystals are also found.

Of interest in connection with these deposits is the report of a recent discovery about a mile west of Belleville, where a shaft developed an ore body 43 feet thick, after passing through 140 feet of barren limestone and chert. This statement, though not verified by actual inspection, is believed to be substantially correct.

MINES SOUTH OF TURKEY CREEK.

The mines south of Turkey creek, belonging to this camp, include those of West hollow, East hollow and Cottonwood hollow; here are the mines of the Gretchen Lead and Zinc company, the Illinois and Missouri Mining company, the Joplin syndicate, E. B. Leonard's, and of Guengerich and Gregg; the Block City mines are also to be included here. These various mines have collectively produced large quantities of ore, but during recent years comparatively little work has been done in them. The following table will give some idea of their productivities:

	Lead ore.	Zinc ore.		Lead ore.	Zinc ore.
	Tons.	Tons.		Tons.	Tons.
1886a East Hollow minea	4	876	1891b Johnson and Copley . . .	.....	400
West " "	27	2,796	Gretchen L. & Z. M. Co ... ..	.....	372
1890b Block City. ....	.....	800	Barbee & Co. ....	.....	266
Black & Co., Buckeye and others.	20	55	1892b J. Copley ....	.....	301
Cottonwood M. Co. ..	.....	32	Gretchen L. & Z. Co ..	3	260
Gretchen L. & Z. Co ..	5	2,074	West Hollow M. Co ...	.....	1,250
Rosamond M. Co. ....	.....	156	West Hollow L. & Z. Co	22	793
West Hollow L. & Z. Co	2	75	1893b Joplin Syndicate.....	.....	454
1891b Cottonwood M. Co. ..	2	212	West Hollow L. & Z. Co	9	420
West Hollow L. & Z. Co	41	953			

a Jno. H. Wilson tables [242].

b State Mine Inspector reports; years ending June 30.

Only one mine was examined here by the Survey, as almost all of the others were out of operation at the time of inspection. This mine we will now describe.

The Guengerich and Gregg shaft.—This shaft is situated at the head of Cottonwood hollow, in the NE $\frac{1}{4}$ of the NW $\frac{1}{4}$ of section 31, on the east slope of the hollow, near the hill-top; it was 140 feet deep. The ore body, consisting of white chert, broken though not greatly brecciated, lies about horizontally in a sheet 6 inches to 6 feet thick; between the fragments and blocks of chert are blende and galena associated with dolomite, calcite, chalcoppyrite and iron pyrite. Over this body of solid ore are irregular, oblong openings of soft ore and mud, into which drifts are carried to heights of nearly 20 feet. At the end of the western drift the exposure is very high, and shows distinct horizontal stratification in the arrangement of the chert layers and of the intervening cavities. Bitumen is quite abundant here, intermixed with the dolomite matrix; some decomposed limestone was found in the ore chert. Following are the productions:

	Lead ore.		Zinc ore.	
	Tons.	Values.	Tons.	Values.
1892a.	1	\$51	716	\$10,552
1893a.	3	130	346	7,266

a State mine inspector's reports, years ending June 30.

It was closely adjoining this mine on the west, in the same section that, the old *Stevens mine* was located, which is referred to by Broadhead and described by Schmidt in the report of 1873. These mines were on the land of the present Gretchen Lead and Zinc company. According to these early descriptions, a shaft was sunk through about 10 ft. of soil and broken chert and dolomitic limestone blocks; the ore was found in a nearly horizontal run, of oval cross-sections, about 20 ft. in diameter, 5 to 15 ft. high and 150 ft long, tapering toward the ends and running in a NE.-SW. direction. This run was filled with broken chert and limestone boulders, containing masses and lumps of galena and blende. The rocks were very much disturbed. The adjoining section, copied from an illustration of Schmidt's, represents the conditions here.

The *Grave shaft*, just south of the middle of the north line of the same section, in Cottonwood hollow, was also sunk at this time. It passed through sandstone and broken chert and limestone blocks, but developed no ore.

The *Bentley mines* were in the NE. $\frac{1}{4}$ of the next section to the west, in West hollow. Schmidt describes the section here as of soft clay and broken chert, between which galena was found in loose pieces and blende in crystal, at various depths down to 35 ft.

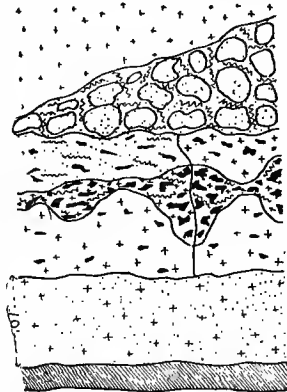


FIG. 143. Section at the old Stevens shaft. (Schmidt)

As a contribution to our description of this camp, we insert here the adjoining small map of the Illinois and Missouri company's mine, which is situated in the extreme southwestern corner of section 30.

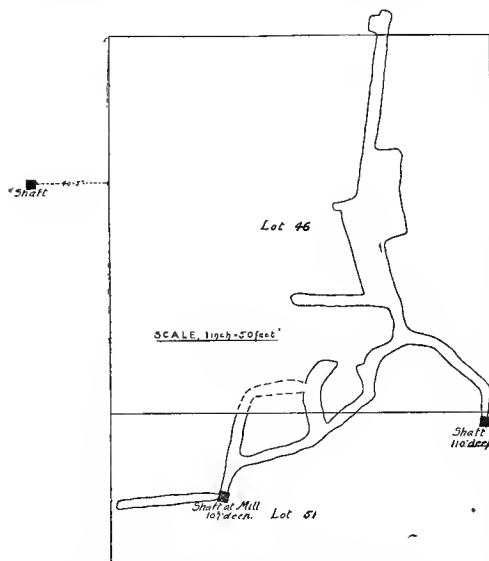


FIG. 144. Map of the Illinois and Missouri mine.
From surveys by S. J. McKee, C. E.

adjacent to the bed of Center creek, so that the waters of that creek had to be diverted and controlled during the progress of mining. Consequently, during the wet season of the year no work could be done. An idea of the amount produced at these mines may be gathered from the following figures:

THE LEHIGH CAMP.

Lehigh is situated about a mile west of Carl Junction, in the north-western corner of the Sub-district. Most of the mines are on the north side, or in the bed of Center creek, but a few south of the creek as far as Sherwood may also properly be included in this camp.

The mines at Lehigh have in the past produced large quantities of ore, notwithstanding the fact that they have had many obstacles to contend with. The principal of these was the fact that much of the best ground lay in and immediately

PRODUCTIONS OF ORE AT LEHIGH.

	Lead ore.		Zinc ore.	
	Tons.	Values.	Tons	Values.
1886a Lehigh Consol.....	25	\$1,150	3,212	\$69,532
1890b Gulch M. & S. Co			100	2,825
Leckie mine			284	6,543
Lehigh D. & M. Co	12	497	2,560	72,209
1891b Franklin Z Co			1,509	34,333
Gulch M. & S. Co			29	788
1892b Franklin Z. Co			1,455	30,472

aFrom Wilson's tables [242]. bFrom Mine Inspector reports, years end June 30.

At the time this locality was visited by the writer the mines were drowned out, no work was in progress, and they, hence, could not be examined. As reported by others, however, the ground consists of a soft, chert breccia, in the clayey portion of which the blende was found. The figures of production show that galena is an unimportant constituent. The blende is often well crystallized, and is of a dark red color. A good deal of marcasite is often associated with it. On the north side of the creek, the ground has caved in over a number of old workings, exposing, in places, a limestone roof and walls, penetrated by chimneys and caverns filled with ore breccia.

During the autumn of 1893 a promising deposit of lead ore was opened on the hill-side, northwest of the creek mines, in the SE. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 12. A shaft was sunk in December to a depth of 90 ft., in soft ground with a black mud matrix.

The Sherwood mines, about one mile southeast of Lehigh, have never been important producers—during the years 1891 and '92 only a few tons of lead ore and less than 100 tons of zinc ore being mined. Work was not in progress there at the time of visit, and hence these mines were not inspected.

THE ORONOGO CAMP.

Mining operations have been prosecuted about Oronogo as long as at any point in the county; in fact, during the first years of mining, they were the principal producers. They were known and were described by Swallow in 1854 as the Center Creek mines, occupying parts of section 31, township 29 N., 32 W., and of section 36 of the adjoining township to the west. From that time on, more or less mining has been prosecuted there up to the present date. The following figures will give an idea of the rates of production at different periods:

PRODUCTIONS AT ORONOGO.

		Lead ore.		Zinc ore.	
		Tons.	Values.	Tons.	Values.
1854a	"Center Creek mines"	210	.....	.....	.....
1873b.	"Minersville"	625	.....	.....	.....
1886c.	"Oronogo Mines Consol."	571	\$27,042	885	\$15,808
1890d	Granby Mining and Smelting Co	225	9,900	788	16,548
1891d	" " " "	222	10,568	1,080	21,269
	Ashcraft, Reynolds & Co.	13	575	15	375
1892d	Granby Mining and Smelting Co	343	14,989	810	16,181
	Margerum M. Co. (Ashcraft)	163	7,714	.....	.....
	Ashcraft, Reynolds & Co.	32	1,495	16	370
1893d	Granby Mining and Smelting Co	539	22,563	472	8,168
	Margerum M. Co.	1,558	65,916	51	699

aFrom Swallow [216].

bFrom Lloyd & Bauman [142].

cFrom Wilson [242].

dFrom State Mine Inspector, year ending June 30.

At the time this locality was visited by the writer, access could not be had to the old and interesting mines north of the town. The new ground of the Margerum land just south of Center creek had, however, just been opened, and the Ashcraft and Hendrickson shaft was examined.

ASHCRAFT AND HENDRICKSON SHAFT.

This shaft was located in the alluvial plain of Center creek, on the south side. It was about 50 ft. deep. The ore consisted of galena in crystals, which were often very large, compounded and sometimes much distorted. This galena occurred in gray or drab clay shales, which surrounded the blocks of chert. The ground is hardly in the condition of a breccia, though the traces of stratification are not very plain. The following are figures of recent production:

From the company's books, by J. R. Holibaugh.

March 2 to Dec. 31, 1892	683 tons lead ore sold for \$29,806
June 1 " " 1893.	2,409 " " " 99,570

THE OLD ORONOGO MINES.

The older workings, which were not visited, were examined quite carefully during the progress of earlier geological surveys. As they presented many features of interest, we will for this reason, as well as for the sake of completeness, abstract portions of these earlier descriptions.

Swallow, on page 180 of the report of 1854, describes the Center creek mines as in a chert breccia, 10 to 30 ft. thick, overlain by from 8 to 10 ft. of brown sandstone "Irregular veins of galena, very variable in thickness, cut through this conglomerate of chert, etc., and through the limestone, in directions approaching an east and west line, and varying from a perpendicular to a horizontal. The galena usually fills the fissure, when it is small, without any vein rock or any gangue; but when the opening is large, the sheet of mineral runs through the middle, the space on each side being filled with clay and crystals of calcareous spar."

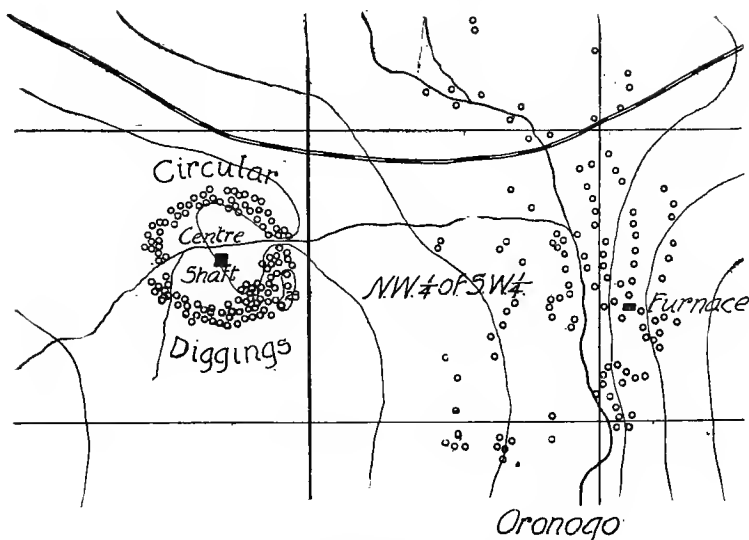


FIG. 145. Map of Oronogo in 1873. (Schmidt.)

The most complete description of these mines appears, however, in Schmidt's report of 1873. Above figure of this page is reproduced from that report, and shows the distribution of the diggings at the time and the peculiar shape of the deposit. The diggings were divided into the Branch diggings, along the small stream east of the postoffice, and the Circular diggings northwest of the postoffice. Schmidt makes a special note here of the presence and prevalence of a dark secondary chert or "quartzite," which occurs both massive and cementing fragments of chert and limestone; it is generally dense and indurated, though he notes that it is sometimes coarsely crystalline and granular; also, through action of the silica-bearing waters on the original chert, it appears in some instances to grade into the latter. We have already referred to similar material in other shafts of the sub-district, but at the time of Schmidt's report it seems to have been encountered only at a few localities.

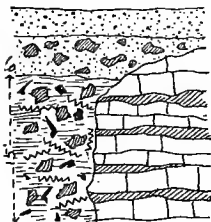


FIG. 146. Section at the Branch diggings. (Schmidt.)

The Branch diggings, along the small stream, appear to have worked ore bodies which occurred in small runs in the usual chert and limestone breccia; in these the galena and blende were distributed in streaks $\frac{1}{4}$ to 6 ins. thick. Secondary chert was quite abundant here, as already stated. In one shaft, at a depth of only 10 ft., a mass of galena 6 to 8 ft. long, and weighing 5 tons, was found loose in the clay. In some of the diggings the contact between the ore breccia and undisturbed limestone was encountered and found to be sharp and distinct, as illustrated in figure 146. Coal and shale were encountered at different points, and, in one series of shafts, a stratum of gray, sandy limestone with streaks of black shale was developed in places as much as 15 ft. thick, and dipping 25° to 40° east; through this limestone seams and specks of galena and blende were found, as is illustrated in the adjoining figure. Galena was also found in seams in fissured secondary chert, associated with much blende; also amethyst in pockets and streaks. In one series of shafts a cave in limestone blocks was discovered, 15 ft. in diameter, filled with mud of yellow and gray clay, gravel, pieces of wood and small crystals and fragments of galena and blende.

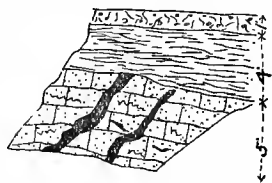


FIG. 147. Section at Branch diggings. (Schmidt.)

The Circle diggings, whose general outlines are well shown on the map, consisted of a large number of different shafts arranged in a circle. Within this circle, the surface of the ground dipped

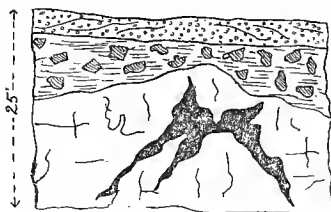


FIG. 148. Section at the Circle diggings. through 12 ft. of black clay, with lumps of coal, overlying other black clays and slate and sandstone, aggregating about 40 ft.; under this, blocks of limestone were passed through, and, at the bottom, 3 ft. of the usual chert breccia was encountered, cemented by sandy limestone, containing blende, galena and calcite; the last blast opened a fissure running in a N.-S. direction, causing a flow of water into the shaft.

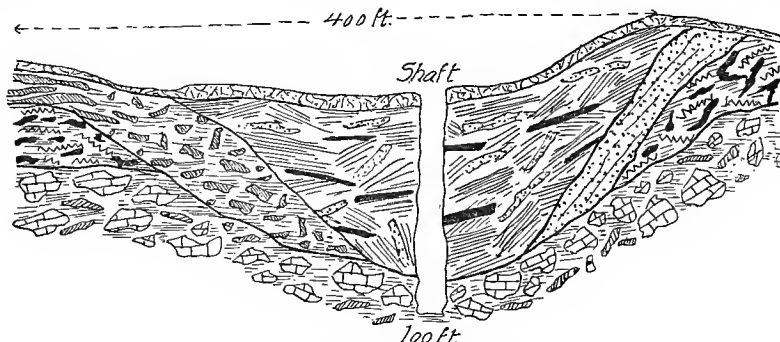


FIG. 149. Ideal cross-section of the Circle diggings. (Schmidt)

The above ideal cross-section represents the conditions here, as illustrated by Schmidt. According to his interpretation, the circular form of this deposit is due to the breaking down of strata into a cavity produced by underground erosion, so that it is of the same nature as the sink-holes so commonly found in limestone formations.

THE ALBA MINES.

An outlying group of mines which is best considered here, occurs about one-half mile south of the town of Alba, in the SW. corner of section 15, and the SE. corner of section 16, township 29 N., 32 W. In 1886, these were new mines, and they have since been operated only at intervals. The yield is consequently not very large. The following figures, applying to three different years, illustrate the rate of production:

PRODUCTIONS OF ALBA MINES.

	Lead ore.		Zinc ore.	
	Tons.	Values.	Tons.	Values.
1866a Alba Mines Consol.	5	\$230	100	\$2,000
1892b Alba Co.	10	250
Alba Mining Co.	24	502
1893c Albatross M. Co. (same as Alba M. Co).....	853	19,253
Alba Co. †.....	221	3,672

a From Wilson's tables [242]. b From Mine Inspector's Reports, years ending June 30.

c From G. Dennison, president.

Two companies are operating here, namely, the Alba company in section 16, and the Albatross Mining company in section 15. The mines of the first company were examined by the writer in some detail.

The Alba Company's mine.—We have at this mine an illustration of an occurrence of ore similar to that of the Circle mines at Oronogo. This is well shown on the adjoining sketch, prepared by the writer while on the ground. To give a thorough understanding of the conditions existing here, we add the following detailed description of the different openings represented on this map.

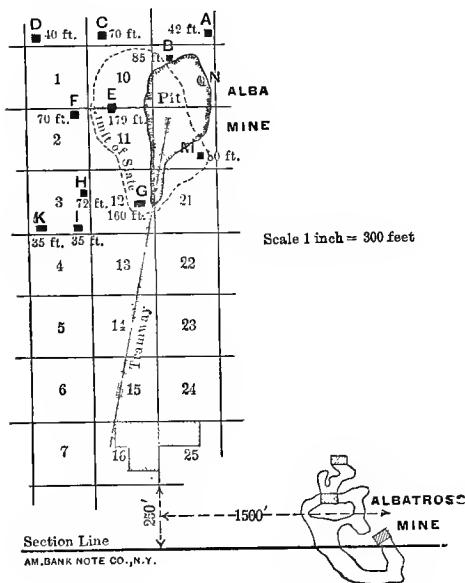


FIG. 160. A circular deposit at the Alba mine.

At I, J, K and L are shallow shafts in which solid limestone was struck.

At M is a shaft 80 ft. deep, which passed through broken ground and about 15 ft. of shale.

The upper run of ore, containing principally blende, was struck at 55 ft.

At N is an undisturbed outcrop of soft, porous chert, weathering red on exposure. Just west of this, between it and the margin of the slate, smithsonite was struck at about 40 ft.

At A is a shaft 42 feet deep, in open chert ground.

At B is a shaft 85 feet deep, in similar ground, with some blende at 70 feet.

At C is a shaft 70 feet deep, through fractured fossiliferous limestone, with some white chert; only small specks of blende were found.

At D is a shaft 40 feet deep, in solid limestone.

At E the shaft is 179 feet deep, and passed through a section illustrated in figure 151.

At F is a shaft 70 ft. deep, through open ground with dolomite, but no slate; at about 65 ft. coarsely crystallized blende is disseminated through the dolomite.

At G is shaft No. 12, 160 ft deep. Only about 15 ft. of slate was passed through here, covered by the surface clay and chert, and underlain by limestone and dolomite blocks; the ore body was struck at about 50 ft., containing some galena and much blende; this continued down to 70 ft. Between 140 and 160 ft. another run of ore was found.

At H is a shaft 72 ft. deep, in which chert and yellow clay were found, containing a little lead.

*From Wilson's tables [242]. †From Mine Inspector's reports, year ending June 30. ‡From G. Dennison, president.

In addition to these openings, numerous shallow shafts were put down in past years beyond the western edge of the open pit shown on the map, and on the eastern side also; these worked the upper run of ore at depths between 50 and 60 ft., which contained lumps of galena, much blende, and some carbonate of zinc associated with clay and chert.

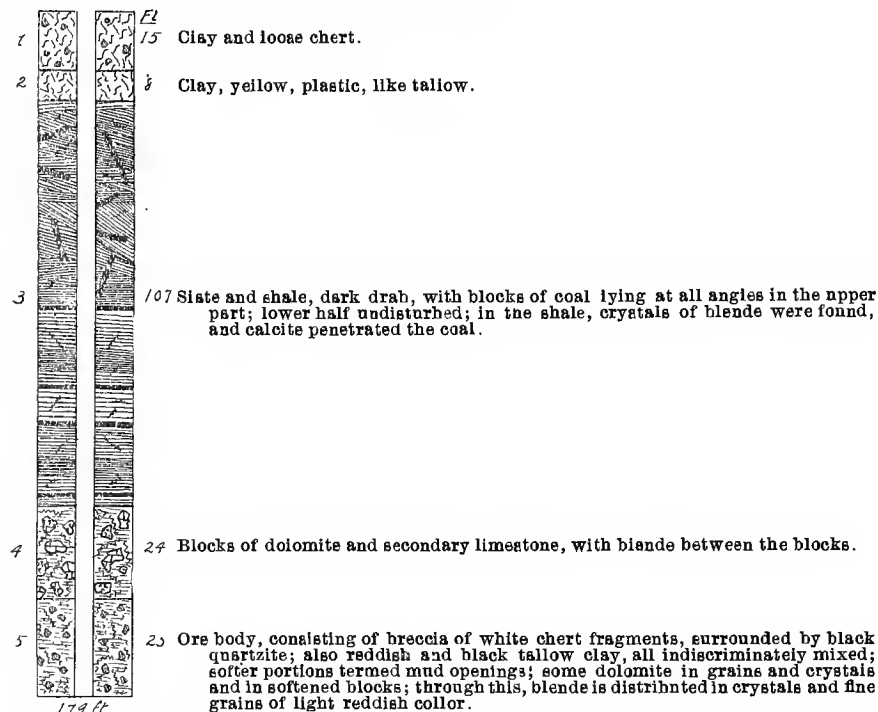


FIG. 151. Section of Alba Co.'s shaft.

During the year 1892, an attempt was made to work this upper run of ore by an open cut or pit, which was sunk at great expense, to a depth of 60 ft. Its outlines are defined on the map. Among other materials, some 35 ft. of coal shale was taken out within the limits shown.

A consideration of all these facts plainly shows that we have here another instance of a coal pocket, around the margin of which the ores occur in a breccia of residuary materials, derived from the Lower Carboniferous rocks. This zone of brecciated material, though irregular, appears to be in the neighborhood of 100 ft. wide, and beyond this, the undisturbed limestone is encountered. A few hundred yards south of the mine, undisturbed limestone is seen in the bluffs along Spring river.

The Albatross mine.—This mine, which is just across the road to the east of the last described, is reported to be in similar ground, and the deposit is associated with slate. Time did not admit of a special examination. The main shaft is 190 ft. deep; the outlines of the workings are shown in figure 150.

WEBB CITY AND CARTERVILLE CAMP.

This important camp of southwestern Missouri came into prominence several years later than did Joplin. Apparently, the first discovery of ore here was about 1873, and in the fall of that year prospecting and mining were in progress. Only shallow work was attempted, however, and the shafts did not exceed 30 or 40 feet in depth, at which point limestone, then considered bed-rock, was encountered, and no attempt was made to penetrate it. Within a few years, however, some of the deeper and large bodies were run upon, and the camp soon attained an important position as a producer. It has maintained this position during recent years, even outstripping the Joplin camp, as is shown by the table of productions by camps given at the beginning of this sub-district. It, therefore, now ranks first in the district, especially in the production of zinc ore.

The outlines of the camp are approximately defined by the limits of the two towns. These include an area of about 12 square miles, in which most of the mines of the camp occur, though a few mines in outlying adjacent tracts will be considered under this heading.

A very large number of openings have been made in and about Webb City and Carterville. They are especially concentrated along a little stream called Mineral creek, which flows between the two towns. Immediately south and southeast of Carterville is also an area of dense mining. On Mr. Holibaugh's blue print property map of the two towns of 1893, there are as many as 700 mines located within their limits, and a number more within a distance of a mile or so. The cut of p. 579, prepared from this map, well illustrates the density. It is manifestly as impossible here as with Joplin, to describe and give records of all of these openings, nor could we even locate them on a small map. An attempt to accurately describe even all the most important would prove futile. It is truly lamentable of how few mines any adequate description or history is preserved. No provisions have been made for maps which would show the extent of the workings, and from which the shape and distribution of the ore bodies over the whole camp might be deduced. Many of these workings are now inaccessible.

A number of the most important mines were examined by the writer during 1892. As time and opportunity did not permit visiting a large number, effort was made to distribute observation equally over the area, and to select such mines as might stand as types. These we will now proceed to describe by groups.

THE SOUTH WEBB CITY GROUP.

The Noble Mining Co.—This company operates a small tract of land of only 5 acres, situated in the southwestern corner of the NW. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 19, on the southern edge of the town of Webb City. It is, along with a number of other mines, in what is known as Sucker flats, on the crest of the prairie hill. Operations were not begun here until about the year 1889. The productions during late years are shown by the following figures:

	Lead ore.		Zinc ore.	
	Tons.	Values.	Tons.	Values.
1891a	164	\$7,862	200	\$4,593
1893a	244	10,980	425	8,925

a From State Mine Inspector's reports; years ending June 30.

LEAD AND ZINC DEPOSITS OF MISSOURI.

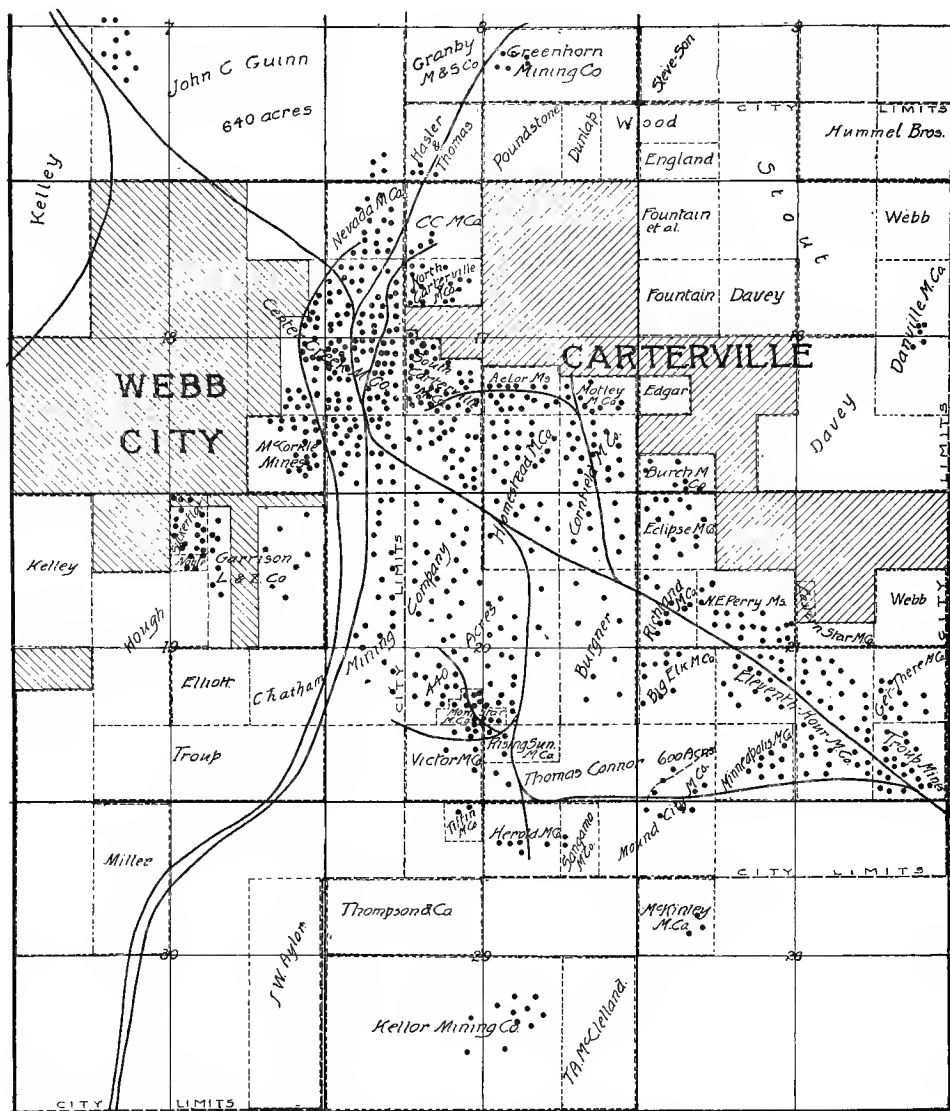


FIG. 152. Map of Webb City, Cartersville and vicinity.
From a map compiled by J. R. Holibaugh, M. E.

At the time of inspection, the total depth of the shaft was 180 ft. Drifts had been driven at four different levels, namely: at 106 ft., 150 ft., 166 ft. and at 180 ft., at the bottom of the shaft. The 166-foot drift was the most extensive. The ore body consisted of fragments of chert surrounded by clay or shale, the latter almost hard enough to be a chert. In this matrix the ore was found, consisting chiefly of blende, which occurred in crystals, especially near the bottom of the shale, close to the chert blocks. A little galena was found, and some pyrite was disseminated in the shale. Large masses of shale were encountered in this drift, distinctly bedded, and these bedding planes were inclined, showing that the material had been disturbed since its deposition. This phenomenon was observed in many other mines of this camp. At the bottom of the shaft, some 15 ft. of chert had been penetrated, and a short drift was driven in it. The chert was of bluish color, very tough and of a gnarled appearance. It occurred in horizontal layers, but the bedding planes were obscurely developed. It somewhat resembled the chert found at Grand falls. Immediately adjacent to the shaft, Coal Measure shale was encountered in a number of diggings. It is here generally divisible into dark-gray micaceous shale, overlying about 20 ft. of black shale, the total thickness being about 50 ft.

Immediately adjacent to this mine are those of the Sucker Flat company, the Quick Work property of the Center Creek Mining company, the Garrison Lead and Zinc company, the McCorkle mine and the Tracy land. These have been important producers in the past, and large amounts of ore have been mined. Time and opportunity did not permit an examination of the ground by the writer. The following figures are given to illustrate the extent of the workings:

	Lead ore.		Zinc ore.	
	Tons.	Values.	Tons.	Values.
1886 ^a Garrison L. & Z. Co.....	62	\$2,829	1,822	\$28,778
McCorkle & Aylor.....	60	2,760	600	10,200
1891 ^b Garrison L. & Z. Co.....	58	2,808	851	18,738
1892 ^b Garrison L. & Z. Co.....	248	11,160	1,522	34,473
1893 ^b Garrison M. Co.....	118	4,477	840	17,638

^a From Wilson's tables [242].

^b From State Mine Inspector's reports, years ending June 30.

In addition, Mr. Holibaugh has contributed the following figures of the Tracy lands obtained from the company's books:

	Lead ore.		Zinc ore.		Totals.
	Tons.	Values.	Tons.	Values.	
1886	2	\$120	378	\$7,008	\$7,128
1887	81	3,394	1,330	26,621	30,015
1888	76	1,839	2,540	62,090	63,849
1889	71	.....	4,142	.....	97,855
1890	432	.....	7,430	.....	205,427
1891	639	.....	12,719	.....	317,007
1892	466	.....	11,466	.....	272,263
1893 (to 1st week in December)	270	.....	10,353	.....	261,831

THE SOUTH CARTERVILLE GROUP,

About one mile southeast of the Sucker Flat mines, is another important group, in the southwestern corner of the corporate limits of Carterville. These include the Victor, Morning Star, Blanton and Wyatt, Rising Sun, Cherokee, Mound City, Kellar and the Pennsylvania (now Acme) mines. They are located in the prairie very near the center of the divide between Center creek and Turkey creek. Large quantities of ore have been produced from these mines. We have not been able to obtain many figures of production from this group, nor did we have opportunity to examine many of the underground workings. The following table will, however, convey an idea of their importance:

	Lead ore.		Zinc ore.	
	Tons	Values	Tons	Values.
1891 Acme <i>a</i>	1½	\$79	.....	.....
Blanton and Wyatt <i>b</i> .....	.....	.....	705	\$16,781
1892 Cherokee M. Co. <i>c</i> .....	.....	.....	612	.....
Rising Sun M. Co. <i>c</i> .....	.....	.....	889	.....
Blanton and Wyatt <i>b</i>	94	4,200	1,088	21,700
Mound City M. Co. <i>c</i> .....	.....	.....	100	.....
1893 Cherokee M. Co. <i>c</i>	14	.....	198	17,931
Blanton and Wyatt <i>b</i>	26	1,100	1,717	33,500
Mound City <i>c</i>	60	.....	570	14,246
Rising Sun <i>c</i>	1	.....	1,308	.....

a From State Mine Inspector's report, year ending June 30.

b From J. R. Hollibaugh, derived from company's books.

c From W. C. Stewart, of Webb City.

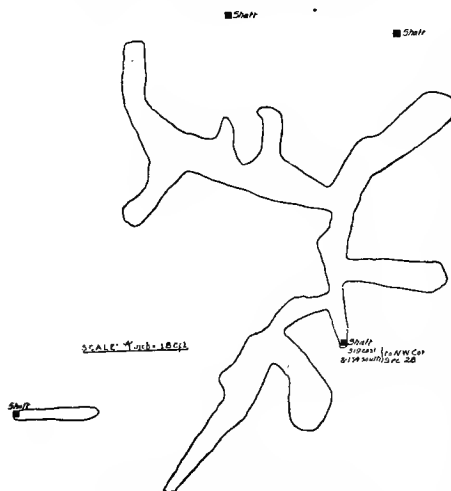


FIG. 153. Map of the Mound City mines. Surveyed by O. Rees, C. E.

Only one shaft was examined, namely, the Victor, which we will now describe; the ground in which the others work is, however, similar. The adjoining map of the Mound City mine is added for reference here.

The Victor Mine.—This mine operates what is known as the Thomas Conner land, and is in the northeastern corner of the SE. ¼ of the SW. ¼ of section 20. It immediately adjoins the Morning Star mine, with which the workings are connected underground. The map of p. 583 shows the extent of these workings. This mine has been one of the largest producers of the group, the product being entirely zinc ore. The following table shows its output during the past four years:

According to a circular of the Carterville Commercial Club, the production for 1890 was 2704 tons zinc ore, at \$51,580; and for 1891, 3319 tons, at \$379,664.

This mine has not been in operation much longer than the period to which these figures

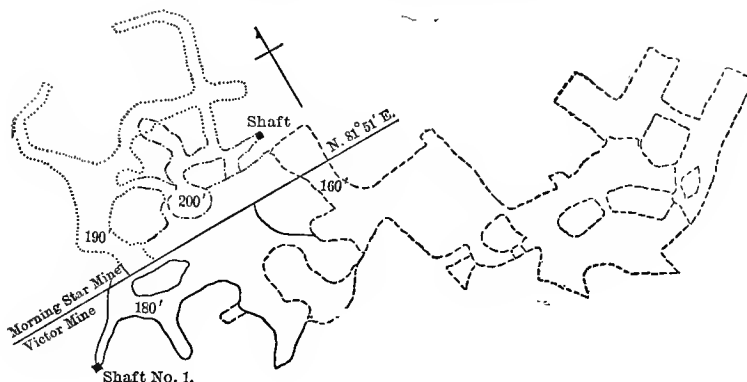


FIG. 154. Map of Morning Star and Victor mine.

From Surveys by A. F. Dannan, C. E.

Scale, 1 inch=120 feet.

	Lead ore.			Zinc ore.	
	Tons.	Values		Tons.	Values.
1890a	1890a	1,147	\$26,999
1891a	1891a	2,383	59,362
1892a	1892a	4,188	102,600
1893a	1893a	2,400	54,000

a From State Mine Inspector reports, years ending June 30.

apply. At the time of inspection the shafts were about 200 ft. deep. No. 3 shaft passed through about 80 ft. of limestone, overlying the ore body. The latter was a chert breccia, the matrix or filling between the chert fragments consisting of clay and a soft, earthy silicified shale or chert (*Anal. No. 378, p. 447*). Masses of dark bituminous shale were also found in the ore body, showing planes of stratification and containing nodules of chert; the layers of shale were seen, however, to dip strongly, in evidence that it was not in its original position. Drifts are opened in this ore body to a height of 70 ft. The chert is very brittle and much shattered, often breaking into long splinters, whence it is called "butcher's knife flint." No black, siliceous and hard secondary chert was seen. The ore, which is almost entirely blende, occurs in massive, crystalline masses between the slabs of chert, and also disseminated through the gangue. Very little pyrite or dolomite were observed.

The fact that shaft No. 3 penetrated a thick stratum of limestone does not necessarily mean that the whole body of ore is covered by such a cap; and the same remark applies to the other mines in this camp which are operated under a limestone roof. On the contrary, at the Victor mine, numerous sink-holes or cavings of old mines were seen, which showed that the cap rock of Lower Carboniferous limestone was penetrating up to the surface in many places by pipe and sink-hole openings, thus furnishing channels for the ready transfer of surface material to underground cavities.

THE SOUTHEASTERN CARTERVILLE GROUP.

In the southeastern part of the town of Carterville, along the branch of the Mo. Pacific railway which runs to Birch Center, is a group of important mines of comparatively recent development. The principal of these are the following: the Troup, the Eleventh Hour, the Richland, the Eastern Star, the Perry and the Eclipse mine. These have been large producers in past years, and

LEAD AND ZINC DEPOSITS OF MISSOURI.

many of the mines are well equipped with steam plants. The following figures, obtained from various sources, will convey a good idea of the extent of mining here:

	Lead ore.		Zinc ore.	
	<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1886 ^a Weston L. & M. Co. (Troup land).....	141	\$6,651	.42	\$857
Aylor Bros (Eleventh Hour)	25	1,250	.....	.....
1890 ^b Eleventh Hour	276	11,942	334	7,491
1891 ^b Troup mine	23	1,077	4,373	96,206
Eleventh Hour	218	9,825	3,162	72,726
Burch M. Co .....	.....	.....	314	6,782
1892 ^b Troup mine	249	11,597	6,707	141,920
Richland	322	14,611	1,838	41,360
Perry mine .....	.....	.....	8	184
Burch M. Co .....	.....	.....	106	2,338
1893 ^b Troup mine	221	9,319	1,523	31,636
Richland	365	16,478	1,743	37,907
Get There M. Co	123	5,052	175	3,410
Eleventh Hour M. Co	462	19,896	16,990	373,776
Minneapolis M. Co	32	1,311	17	327

^a From Wilson's tables [242].

^b From State Mine Inspector's reports, years ending June 30.

In addition, Mr. Hollbaugh has contributed the following, obtained by him directly from the companies' books.

	<i>Tons lead ore.</i>	<i>Tons zinc ore.</i>	<i>Total values.</i>
Richland M. Co., 1891	154	629	\$18,742
" " 1892	470	2,235	70,436
" " 1893 (to Nov. 18)	376	734	29,966
Troup mine, 1893 (to Nov. 18)	228	613	18,483
Perry mines (July, 1892, to Nov. 18, 1893)	39	3,626	76,196
Eclipse mine	62	96	4,000
Eastern Star (June, 1892, to Nov. 1, 1893) .....	.....	4,186	91,961

Two mines were selected out from this group for examination by the writer, and they may be considered types for the whole.

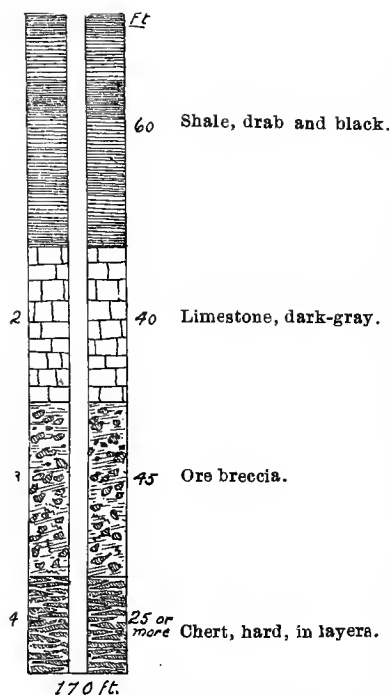


FIG. 155. Section at the Richland mine.

and clay and dark earthy secondary chert. No dolomite and no calcite were observed. Some lead was found in the upper portions of the workings, and the blende occurred in the lower part in crystalline masses and layers, and also disseminated through the breccia. Very little pyrite is found here. No indications of stratification were observed in the breccia or chert, but the constituent parts are arranged, apparently, without any particular order.

Other mines of this group might have been examined had time permitted, but, at others, there was no work going on at the time. It is thought, however, that this brief description will sufficiently indicate the general nature of the ground. The limestone overlying the great mass of brecciated material is a marked characteristic. The presence of overlying Coal Measure shales is also to be noted.

THE WEBB CITY-CARTERVILLE GROUP.

Under this heading we include a number of the most important mines in the camp, operating lands lying principally between Webb City and Cartersville, on both sides of Mineral creek. A portion also lie immediately south of Cartersville. In this group we include the mines of the Center Creek, the Nevada, the North Cartersville, the South Cartersville, the Ealy, the Motley, the Homestead and the Corning Mining companies. It was within the limits of these lands that the first mining about Webb City was done, and work has continued there uninterruptedly to the present day. Undoubtedly the bulk of the ore output of the camp has been from this group, and this largely from the 160 acres owned by the Center Creek Mining company. The following table, compiled largely from the State Mine Inspector reports, will give an exact idea of the productivity of these mines:

The Richland mine —The shaft on the Hatcher land of this company was examined. It is located in the SW. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 21. The drift is at 145 feet, the shaft is 170 feet deep, and the adjoining section was encountered in sinking it, according to the description of the foreman.

The ore breccia consists of white chert fragments, surrounded by a matrix of shale or clay, the latter sometimes hard and quartzose (Anst. No. 346, p. 447). Portions of the ashly material are seen to be distinctly stratified, but dip at an angle of 20° or more. Galena is found near the top of the breccia, and lower down blende occurs, in crystals attached to the chert alaba and fragments; the latter is also found both massive and disseminated through the gangue. No calcite and no dolomite were observed; little pyrite was found here; no tallow clay was noticed. Shales overlying the limestone are of general occurrence here and have been passed through in a number of shafts in the immediate vicinity. The productions of this mine are given in the preceding table.

The Eleventh Hour mine —The Hardin and Preston shaft on this property was examined by the writer. It is located in the NW. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 21, near the railway. The shaft was 140 feet deep, the upper 80 feet having been successively in shale and massive limestone, while the lower 60 feet was in the usual ore breccia. The drift of the mine was in the lower 30 ft. of this ore body. The breccia consisted of white, fractured chert fragments, in a matrix of 'sand' and clay and dark earthy secondary chert.

No dolomite and no calcite were observed. Some lead was found in the upper portions of the workings, and the blende occurred in the lower part in crystalline masses and layers, and also disseminated through the breccia. Very little pyrite is found here. No indications of stratification were observed in the breccia or chert, but the constituent parts are arranged, apparently, without any particular order.

Other mines of this group might have been examined had time permitted, but, at others, there was no work going on at the time. It is thought, however, that this brief description will sufficiently indicate the general nature of the ground. The limestone overlying the great mass of brecciated material is a marked characteristic. The presence of overlying Coal Measure shales is also to be noted.

LEAD AND ZINC DEPOSITS OF MISSOURI.

	Lead ores.		Zinc ores.	
	Tons.	Values.	Tons.	Values.
1886 ^a Center Creek M. Co. *.....	997	\$51,308	14,095	\$271,162
Nevada M. Co.....	142	6,785	1,704	31,183
Carterville Co. Consol. (N. & S. Carterville Co.).....	1,541	73,434	5,617	110,214
Motley M. Co.....	26	1,195	46	1,067
1890 ^b Center Creek M. Co. *.....	1,290	59,108	23,654	572,188
Nevada M. Co.....	146	5,779	963	20,826
Motley M. Co.....	393	16,920	1,183	29,575
Daugherty, Davey & Daugherty (Cornfield).....	412	17,882	2,188	49,012
Davey, Tower and Tower, Davey & Co. (N. & S. Carterville Co.).....	603	27,162	3,008	70,850
1891 ^b Center Creek M. Co. *.....	1,128	52,719	20,706	469,897
Nevada M. Co.....	165	8,250	1,294	28,119
Daugherty & Davey (Ealor).....	266	13,407	1,472	33,556
Daugherty, Davey & Daugherty (Cornfield).....	325	17,429	993	19,896
Davey, Tower & Co. (S. Carterville Co. land).....	126	6,048	1,082	23,804
Tower, Davey & Co. (N. Carterville Co. land).....	252	12,096	1,272	27,984
Motley M. Co.....	413	19,824	1,170	27,495
1892 ^b Center Creek M. Co. *.....	873	41,890	12,758	306,187
Nevada M. Co.....	128	5,888	750	15,610
Daugherty & Davey (Ealor).....	144	6,640	1,016	23,376
Daugherty, Davey & Daugherty (Cornfield).....	409	18,814	786	16,969
Davey, Tower & Co. (S. Carterville Co.).....	60	2,971	553	12,028
Tower, Davey & Co. (N. Carterville Co.).....	248	11,921	1,015	20,884
Motley M. Co.....	228	10,488	1,349	33,063
1893 ^b Center Creek M. Co. *.....	710	23,648	11,113	231,381
Daugherty & Davey (Ealor).....	167	7,014	423	7,825
Daugherty, Davey & Daugherty (Cornfield).....	375	15,742	150	2,703
Davey, Tower & Co. (S. Carterville Co.).....	66	2,785	834	17,931
Tower, Davey & Co. (N. Carterville Co.).....	159	6,686	615	12,310
Motley M. Co.....	127	5,588	934	20,541

^a From Jno. N. Wilson's tables [242]. ^b From State Mine Inspector; years ending June 30.

* A small portion of the Center Creek Co.'s output is from their Quick Work land on Sucker Flata.

In addition to the above table relating to the productions of various years, we add the following statement of the total productions of a few of these mines:



THE SINK OF THE NEVADA MINE, CARTERVILLE.

	Lead ore. Tons.	Zinc ore. Tons.	Total values.
Carterville M. & S. Co., 1876 to August, 1887 (including lands of N. & S. Carterville companies) <i>a</i>	9,877	125,699	\$3,500,000 (Approximate)
Ealor land, from beginning to December 1, 1893 <i>b</i>	1,812	8,735	277,226
Cornfield, from beginning to December 1, 1893 <i>b</i>	1,597	2,649	128,940

a [123, p. 26]. *b* From J. R. Holibaugh, as obtained from the companies' books.

As is natural to expect, many of the mines over this long-worked area are now abandoned and are inaccessible. Some have caved in, and furnish excellent exhibitions of the character of the ore body and its relations to the limestone country rock. The illustrations of the plate opposite this page are from a photograph of a cave-in on the Nevada company's land. It gives some idea of the dimensions of the workings. The overlying limestone rock, which is here about 10 ft. thick, is shown just below the dump-pile on the surface.

The Center Creek Mining Company.—This company owns 160 acres of this area, including the NE. $\frac{1}{4}$ of the NW. $\frac{1}{4}$, the SW. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ and the NW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 17; also the SE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ and the NE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 18. It was within this area that the original Webb City mines were operated in 1876, and from that time to the present a very large number of different shafts have been sunk. An idea of the number of the openings will be conveyed by reference to the small map opposite page 581 of this report. The whole surface of the ground is covered by dump-piles of refuse chert and "chsta" obtained from dressing of the ore.

As is shown in the preceding tables of production, these lands have yielded large quantities of ore during the past few years, but their large yield has not been confined to this short period. From July 1, 1876, to June 22, 1889, according to a prospectus and report of the company, prepared by Mr. J. R. Holibaugh and others, the total value of the lead ore produced was \$572,000, while that of the zinc ore was \$2,161,000. The following table gives the outputs of the mines of this company during the past 13 years:

	Lead ore. Tons	Zinc ore. Tons	Total values.		Lead ore. Tons.	Zinc ore Tons.	Total values.
1881 <i>a</i>	\$175,704	1888 <i>b</i>	969	13,739	\$370,581
1882 <i>a</i>	223,488	1889 <i>b</i>	1,646	18,941	517,698
1883 <i>a</i>	158,831	1890 <i>b</i>	1,296	23,023	600,199
1884 <i>a</i>	197,211	1891 <i>b</i>	885	17,266	417,697
1885 <i>a</i>	211,600	1892 <i>b</i>	955	11,774	298,558
1886 <i>a</i>	341,447	1893 <i>b</i> to Oct. 81 * ..	478	7,631	163,627
1887 <i>b</i>	820	14,479	282,219				

a From prospectus and report of the company.

b From J. R. Holibaugh, as obtained from the company's books.

* In addition, the company has about 1600 tons of blende in bins, which is not included in the above statement.

Only a few of the mines of this company were accessible for examination at the time of inspection. The one offering the best opportunity for study was selected, and this we will now proceed to describe.

The Beasley Shaft of the Center Creek Mining Co—This shaft is situated in the NE. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 17. It was about 140 ft deep. A stratum of limestone was struck at a depth of about 60 ft. and continued to about 80 ft. Under this, the usual breccia was encountered, consisting of white chert fragments, surrounded by dark mud or clay, in part indurated and quartzose. Some blocks of hard, siliceous limestone, similar to that overlying the ore body, were also found buried in the breccia. Some

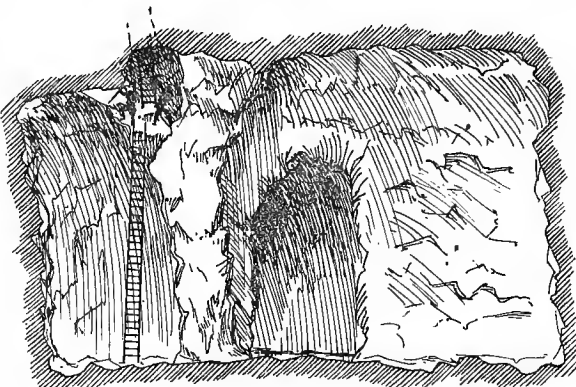


FIG. 156. Sketch of stope in the Beasley mine.

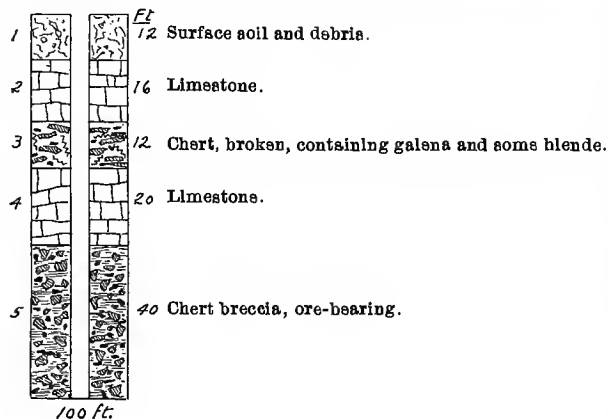


FIG. 157. Section near the Beasley shaft.

Especially worthy of note in this section is the occurrence of the bed of broken chert, carrying lead and zinc ore, between the two limestone beds and overlying the main ore body. This is an unusual occurrence in the camp.

As illustrating the extent and distribution of the workings of other mines of this group, we add the map of the opposite page. Of the Center Creek mines, no maps could be obtained.

Reviewing what we have said concerning the Webb City and Cartersville camp, it will be seen that the principal distinguishing features are: 1) the presence of a stratum of limestone of variable thickness, which overlies the main ore body; 2) the frequent presence of bodies of Coal Measure shale, and sometimes of coal-beds above this limestone roof, the shales often reaching as much as 50 ft. in thickness;* 3) the great size of the ore body and its complete brecciation, no evidence

galena was found, but the metalliferous mineral is principally blende; this occurs disseminated in the matrix and also in crystals, or massive, frequently cementing fragments of chert. Some pyrite and a little dolomite and calcite were also found. The sketch on this page conveys an idea of the size of the drifts and the manner of working the ore. These drifts are often 50 and 60 ft. high.

In a shaft on a lot immediately south of this one, the section of figure 157 was passed through, according to information furnished by the foreman in charge.

*At some points the coal-bed is of sufficient thickness and extent to warrant mining, and during recent years such a pocket northwest of Webb City has yielded several thousand tons of coal.

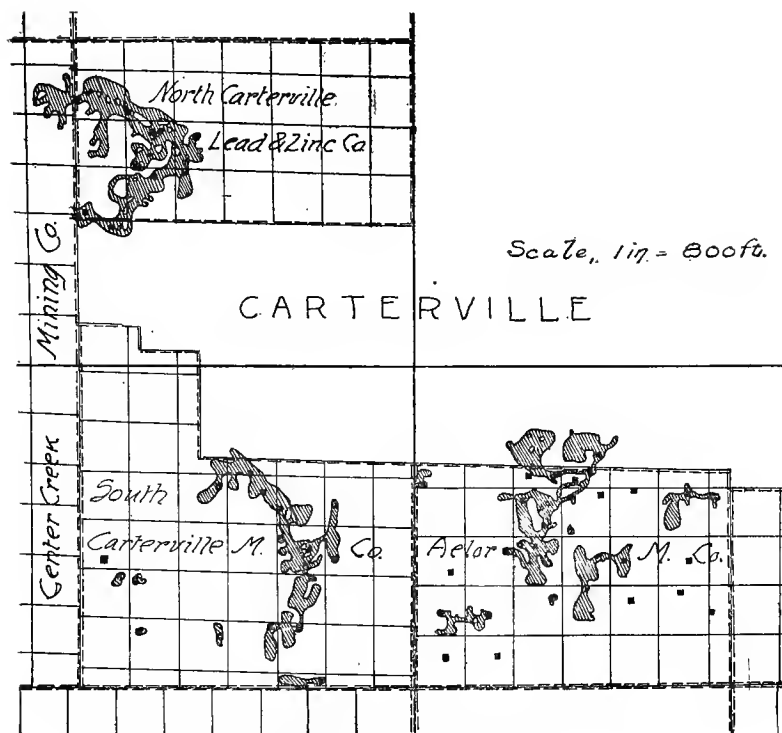


FIG. 158. Map of Carterville L. and Z. Co. mines, S. 17, T. 28 N., 32 W.
From Surveys by Geo. H. Bradford, C. E.

remaining in the large mines examined that the materials of the ore bodies were ever stratified; 4) the inclusion in this ore breccia of large masses of shale, distinctly bedded and dipping at various angles, indicative of disturbance; 5) the preponderance of zinc minerals over lead minerals, as is clearly shown by the statistics of production given, a very small percentage of the output being lead ore—probably less than one per cent, if measured by tons.

THE CARTHAGE CAMP.

The principal mines of the Carthage camp belong to a group on the north-western edge of town, just south of Spring river and close to the Missouri Pacific railway depot, and to another group two or three miles southwest of these. In addition, we shall refer, however, under this heading, to a few scattered deposits, some lying several miles east of Carthage, adjacent to Spring river, and others several miles south of Carthage, on Center creek.

Mining in the vicinity of Carthage was started at quite an early date. Lead ore was dug there as far back as 1854, but the larger developments have been confined to comparatively recent years, with the exception of that at Pleasant Valley, where mining was in progress over twelve years ago.

Though the quantity of ore which has been produced from the Carthage mines is considerable, it is still very much less than that of either the Joplin or Webb City camps. The number of mines operated there at any one time has not exceeded one-half dozen. The following table, derived from the Mine Inspector reports, shows the production of these mines during the past four years. Those near the Missouri Pacific depot did not produce anything before 1889.

PRODUCTIONS OF CARTHAGE MINES.

		Lead ore.		Zinc ore.	
		Tons.	Values.	Tons	Values.
1890..	Globe M. & M. Co. (5 miles SE. Carthage)			100	\$2,800
	Herrin & Meyere (Mo. P. depot)	33	\$1,650		
	Hubb & Puckett " "	88	4,059	64	1,418
	Little Jersey L. & Z. Co. (3 miles SW. Carthage, formerly of Carthage L. & Z. Co.)			764	23,000
	Myers & Jemmlison (Mo. P. depot)			20	520
	Porter M. Co. " "			1,591	40,775
1891..	Coshocton M. Co. " "			606	14,700
	Jasper Co. M. Co. " "	65	4,100	44	1,100
	Magnett M. Co. (5 miles SE. Carthage)			30	690
	Myers & Jemmlison			1,195	30,257
	Pacific M. Co. (Mo. P. depot)			200	4,800
	Pleasant Valley M. Co. (3 miles SW. Carthage) ..			550	14,300
1892..	Carthage M. Co. (at Pleasant Valley)			674	15,500
	Myers & Jemmlison			1,440	34,560
	Pacific M. Co.			600	15,600
•	Porter M. Co.			1,471	35,312
1893..	Cave Spring M. Co.	4	148	450	9,441
	Myers & Jemmlison			360	7,920
	Pacific M. Co.			187	3,155

Several of the more important of these mines were examined by the writer during the summer of 1892. The results of these examinations we will now proceed to give.

The Linzee mines.—These mines are located near the center of section 8, about a half mile west of the town limits.

The shaft here was 170 ft. deep, and in sinking it the materials of figure 159 were passed through, according to the report of the superintendent:

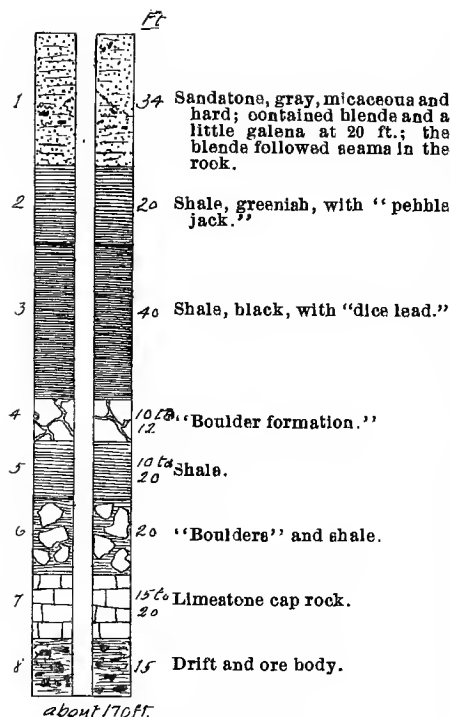


FIG. 159. Section of Linzee shaft.

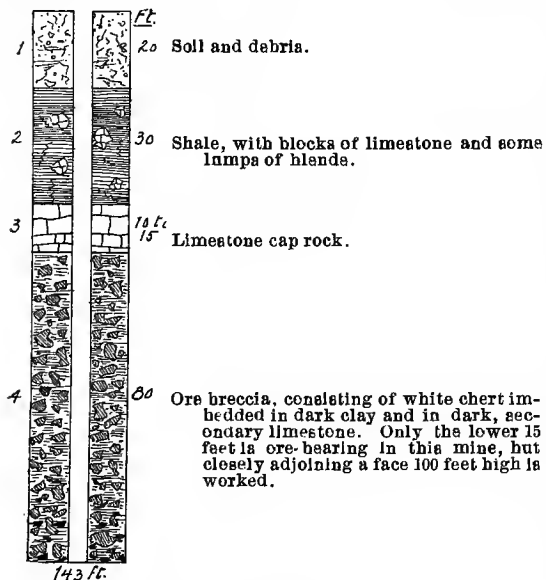


FIG. 160. Section of the Cornell shaft.

The ore body consisted of a chert and limestone breccia, the fragments being cemented by dark secondary limestone and hard, dark shale; a little undecomposed dolomite was also found, but no calcite was seen, and no talow clay, though the latter is said to occur in small quantities. The metalliferous minerals are exclusively blende of a variety called "roan jack"; no galena was found. The blende is imbedded in the limestone and shale matrix. No pyrite was observed. Slickensided surfaces were seen in the mine, indicating more or less movement. Just north of the shaft is a crop, or "bar," of hard, indurated sandstone, containing a few scales of mica. This sandstone and the upper six members of the shaft section are doubtless to be referred to the Coal Measure formation.

Reference to mines in this same section, in which galena was found in the chert and soil, is made by Swallow in his report of 1854; he also notes the presence of brown sandstone here, which he classifies as "feruginous." Broadhead also refers to the Carthage mines, on Tower & Regan's land, in the NE. $\frac{1}{4}$ of this section. He notes the occurrence of barite with limonite, this being the only locality in the county where he found the former mineral; he refers to stigmairia and fern impressions in the shale and sandstone.

No figures of production were obtained relating to this special mine.

The Cornell shaft at Pleasant Valley. This shaft, located in the NE. $\frac{1}{4}$ of section 18, is adjacent to the mines of the Pleasant Valley Mining company, and was operated by the Carthage Mining company. The shaft was 145 ft. deep. According to the recollection of the superintendent, the materials shown in the accompanying section were encountered in this shaft, successively from the top downward.

Blende is the only metalliferous mineral found, no lead or silicate of zinc having been taken out—though both silicate and galena have been dug in the surface clays, above the cap rock. The blende is disseminated through the matrix, and is fine and granular. No talow clay is found here, and little or no dolomite; a good deal of calcite was observed, in crystals. The ore is characterized as hard, and has to be blasted.

In the adjoining shafts, white Lower Carboniferous limestone has been sunk through continuously to depths of 180 ft.; while at immediately adjacent points the ground is soft and open from top to bottom, showing great irregularity in the decomposition of the country rock.

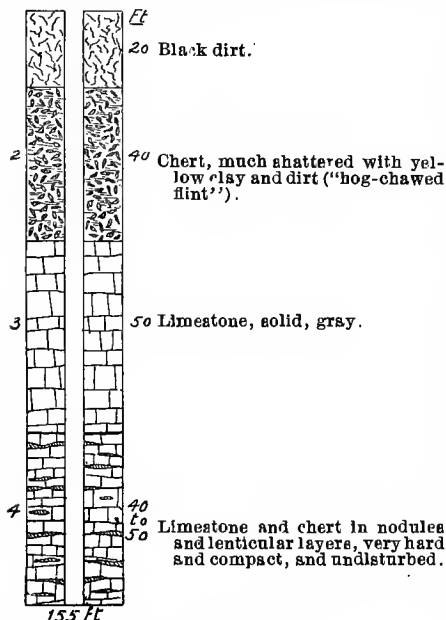


FIG. 161. Section at the Porter shaft.

2) soft black clay or "aelvage," enclosing fragments of chert with blende disseminated throughout.

About 120 feet east of the shaft, at the lowest level of the mine, drab and black shale was found containing blocks of coal. Here the ground was loose and broken, up to the surface; but, about 200 feet farther east, another limestone "bar," similar to that in which the bottom of the shaft was sunk, was encountered.

The Myers & Jemison mine.—This mine is another of the group near the Missouri Pacific railway depot. The shaft is not over 200 yards north of the Porter shaft. When examined by the writer two drifts were operated, an upper one at 120 feet and a lower one at 157. No solid limestone was struck in the shaft, but the ground contains many blocks of that rock and of chert. In the upper drift the ore body consisted of clay and dark drab shale, surrounding fragments of chert and rounded blocks of limestone, and also intermixed with large masses of that rock. The "silicate" of zinc, which is the principal metalliferous mineral, is distributed through this material; some galena and blende are found at points remote from the shaft. In the lower level most of the blende occurs; however, there is also more chert there, and the ore body is firmer and harder. Calcite is quite common, and a little dolomite is also found; some pyrite was observed.

Immediately north of Carthage no mining is done, though Broadhead, in his report of 1873, refers to particles of blende found in dark bituminous limestone in a well about 6 miles north of town.

East of Carthage there was more or less mining in past years, but the work was on a small scale and the output comparatively insignificant. In section 7, township 28 N., 29 W., about nine miles east of Carthage, Broadhead referred to several shafts in 1873, though no lead or zinc was found in them at the time. In sections 8 and 17, township 28 N., 30 W., about five miles southeast of Carthage, some mining has been done; the Globe M. & M. company, which has a place in the table of productions on page 590, is near this locality. At Dudley's mill, on Spring river, in section 17, township 28 N., 29 W., Broadhead notes that two wagon loads of lead were dug out of the

Mining was done in this same section, 20 years ago, and a number of deposits in which lead and zinc ores were found were referred to by Broadhead in 1873. Quite extensive mining was in progress here about 12 years back, and the value of the output of blende, between August, 1882, and May, 1884, is placed by Wilson at \$40,000. Work ceased after the latter date, but was resumed in 1886, and, between November of that year and March 1, 1887, \$10,000 worth of blende was mined.

The Porter mines.—This mine has produced more ore than any one other mine of the Carthage camp, as can be seen by reference to the table on page 590. It is located quite close to the Missouri Pacific railway depot, in the NE $\frac{1}{4}$ of the NW $\frac{1}{4}$ of section 4. The shaft was 154 ft. deep, the top being about 20 ft. below the level of the railway track. The accompanying section (figure 161) of the materials encountered was given by the mine boss.

About 20 feet east of the foot of the shaft, soft ground was drifted into. This consisted, in succession proceeding from the shaft, of: 1) shattered chert in clay, followed by a layer of black, massive and somewhat granular zinc ore called "calamine," but really amethionite;

stream bed. Broadhead also refers to the Ricokey diggings, in section 17, township 28 N., 30 W., where several shafts were sunk, penetrating red clay and chert into limestone. Sand and clay shale were also found here. The Davis mine, in the NW. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 29 of the same township, is also described by him, the ore occurring in small pieces in red clay and chert, and also in a small crevice in limestone.

South of Carthage, along Center creek, there have been a number of openings, some of them of quite recent date. The Beville Mining company's shaft, in the SW. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 27, township 28 N., 31 W., was examined by the writer. The shaft was about 123 ft. deep, and penetrated Coal Measure black shale and coal; also massive drab limestone which apparently overlies the shale, but this could not be satisfactorily determined; indurated, micaceous sandstone was also found here. Drilling was in progress at the time about one mile east of this shaft, but the results were not learned. In section 33, of the same township, Broadhead states in his report of 1873, that extensive mining had been done in the past; several pits 50 ft. deep showed alternations of chert and red clay from the surface downward; in some shafts, fine-grained limestone was encountered at 10 ft.; at the bottom of a shaft 50 ft. deep, 10 inches of coal was found, and also fine-grained sandstone with stigmatalia impressions, while, closely adjoining, Lower Carboniferous limestone was encountered in shallow pits.

In the NE. $\frac{1}{4}$ of section 12, township 27 N., 30 W., was what was known as the Perry mine. Broadhead describes many shafts here. In one pit, 25 ft. deep, chert and clay were passed through to a depth of 19 ft., under which was found blue limestone containing blende; in another pit galena was found in clay and in cubic crystals in limestone; in still another shaft zinc ore was found in a "pocket-shaped longitudinal mass," giving out in one direction, but thickening in others; zinc blende was also found disseminated in limestone; calamine and calcite were observed.

THE SCOTLAND CAMP.

The little postoffice of Scotland is situated about six miles southwest of Carthage and seven miles east of Joplin. About it and the adjoining settlement, known as Burch Center, more or less mining has been done during the past 25 years. At present, very little work is in progress, and opportunity was not afforded to examine the underground workings at the time planned to visit this locality. Considerable space is, however, devoted to the mines of this camp in the report of the Geological Survey for 1873, and from these we will make a few brief extracts.

The Brock mine was in the SW. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 7, township 27N., 31W.; a number of shafts, some as deep as 46 ft., had been sunk, penetrating 30 ft. of red clay and chert, with 15 ft. of gray, coarse dolomitic limestone. The ore was found in crevices at the bottom, in a cherty breccia cemented by dolomite.

The Fleming diggings were in the NW. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 6, and several shafts were sunk here through clay down into the limestone country rock.

The Grove Creek diggings were the principal operations at this early date in the NW. $\frac{1}{4}$ of section 12, and some work was done here before the war. Broadhead and Schmidt describe a number of shafts, none over 50 ft. deep; lead ore was found near the surface, in the clays and chert debris, and at the bottom of the shaft a breccia of chert and limestone, with calcite, clay, galena, blende and silicate, was encountered. In the Tussinger shaft, at a depth of 55 ft., layers of black shale and soft sandstone were found.

The Burch diggings, about two miles east of Scotland, in the SW. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 11, were also operated at this date. The shafts were 30 to 40 feet deep, and galena, cerussite and amithsonite were mined. In one shaft galena was found diffused in a buff, soft rock, the smithsonite being in lumps and slabs.

During recent years most of the mining of this camp has been about Burch Center. The production of the Burch Mining company during two years, according to the Mine Inspector reports, is shown in the following table:

	Lead ore.		Zinc ore.	
	Tons.	Values.	Tons.	Values.
1891 Burch M. Co.....	314	\$6,782
1892 (3 mines 140 ft. deep).....	106	2,338

In 1886, according to Jno. N. Wilson, the productions were as follows:

	Lead ore.		Zinc ore.	
	Tons.	Values.	Tons.	Values.
Johnson mines	81	\$3,743	.....	.....
Burch L & Z. Co .....	.....	.....	78	\$1,560

THE SAGINAW OR THURMAN CAMP.

The Saginaw camp includes a group of mines extending about two miles north of Thurman postoffice, on the east side of Thurman creek and along its tributaries. Mining has also been carried on here for quite a long period, and diggings were described in the Survey report of 1873.

The Thurman diggings, in the NE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 30, were described by Schmidt as in clay and chert and fine-grained limestone which occurs in alaba and blocks over the solid country rock; chert breccia was found cemented by yellow, sandy limestone containing crystals of galena and blende; decomposed dolomite also occurs; calamine was found in masses enclosing crystals of galena; some calcite crystals. The clay associated with these ore bodies was both gritty and ferruginous, and sometimes of the texture and consistency of tallow clay; in this, loose masses of galena were imbedded; galena was also found in fine seams running through the chert. Many old shafts have been put down at this point.

The Johnson diggings, near the middle of section 20, consisted of shafts sunk through ground containing blocks of coarse gray, apparently secondary limestone, enclosing fluid bitumen, crystals of galena and angular chert. Several shafts were also sunk through broken chert and limestone blocks with dolomite in sheets between; in this, loose galena occurs, along thin and narrow runs, the galena being found attached to the chert; brown clay and tallow clay were in streaks and masses; occasionally loose masses of calamine were found.

During recent years the productions of this camp have been as follows, according to the State Mine Inspector (years ending June 30):

	Lead ore.		Zinc ore.	
	Tons.	Values	Tons.	Values.
1891 Spurgeon mine.....	2½	\$42	.....	.....
1892 Saginaw L. & Z. Co.....	40	1840	20	\$200
1893 " "	20	800	20	240

The following descriptions of mines recently worked in this camp are by Mr. Robertson, from observations made by him in 1891:

Saginaw Lead and Zinc Company.—This company was composed mainly of residents of the town of Saginaw, Michigan. They owned about 800 acres in this county, but only a portion of this land was operated, viz.: the SE. $\frac{1}{4}$ section 30, and the SW. $\frac{1}{4}$, SE $\frac{1}{4}$ section 20. The land was leased to four companies, who sublet the lots to individual miners. The companies working on the land in 1891 were:

1. Valley Mining Co., SE. $\frac{1}{4}$, S. 30.
2. J. L. Llewellyn & Co., SE. $\frac{1}{4}$, S. 30.
3. Hay & Asher, SE. $\frac{1}{4}$, S. 30.
4. Moore & Blackburn, SW. $\frac{1}{4}$ SE. $\frac{1}{4}$, S. 20.

The mines all lie in the upper part of Lower Carboniferous limestone, here largely represented by chert. They were all quite shallow and very wet. The ore was almost entirely allicate of zinc, of a very good quality, and occurred with much clay, largely interbedded in the broken chert, and also filling the interstices to some extent. The ore bodies were apparently small, but very numerous. No shaft had been sunk more than 50 feet below the surface. The chert, here forming much of the country rock, is a light colored, hard but very brittle rock, of the general character found in this formation. The clay is dark red, tough and plastic, of the variety generally known as joint-clay.

This property was once very rich in residuary deposits of lead in the overlying clay. In 1876-77, it is estimated that about 7000 tons of ore were produced from this land. There is but little lead produced now.

Fairbanks mine, in NW $\frac{1}{4}$ SE. $\frac{1}{4}$ S. 20, W. H. Fairbanks leased 40 acres from Tower & Burch, of Carthage, and was mining at depths of less than 50 feet, producing considerable galena and allicate. From 1876, when mining began, to 1891 (July), 350 tons allicate and 300 tons lead ore had been produced.

East of Thurman, within a distance of four or five miles, are a number of shafts owned by different mining companies, upon which some prospecting has presumably been done. No records of results were, however, obtained.

At High Point, about six miles east, in the NE. $\frac{1}{4}$ of section 6, township 26N., 31W., some little mining has been done, but no examinations of the deposits have been made.

THE SPRING CITY MINES.

This group of mines is situated south of Shoal creek, about the center of section 10, township 26N., 33W. Prospecting was done here for a number of years, but not until 1892 was much encouragement found in the results, and not until early in 1893 were shafts sunk and large deposits of ore opened out. These mines are remote from others, and furnish an instance of the way new deposits are developed in ground remote from the centers of mining, and in ground which once stood condemned as barren. A number of shafts have been sunk here.

The Alpha shaft was one of the first opened; it is in the NW. $\frac{1}{4}$ of the SE. $\frac{1}{4}$. Comparatively little ore was mined here, but much of interest bearing upon the character of the deposits was developed. The following section obtained from the superintendent, Mr. J. W. Allen, is hence included:

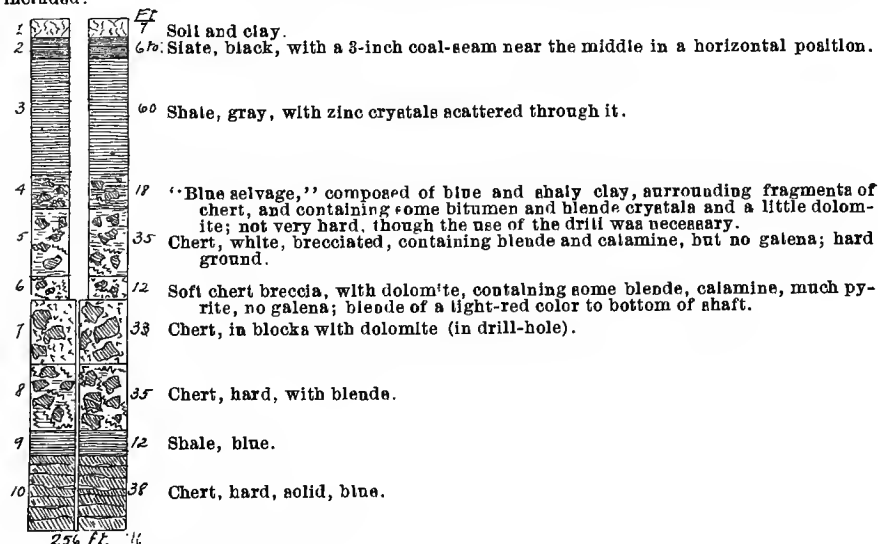


FIG. 162 Section of the Alpha shaft.

This shaft was evidently in a pocket of Coal Mesanre rocks, little, if any, disturbed, as is shown by the horizontality of the coal-seam. Only 160 feet southeast of this shaft, however, a drill-hole struck solid limestone at a depth of 18 feet, and no shale. About 100 feet north of the shaft is another, 50 feet deep, in broken chert, with no shale.

The principal mining at the time of inspection, in November, 1893, was about a quarter of a mile north of this shaft, near the SW $\frac{1}{4}$ of the NE $\frac{1}{4}$ of section 10. The shafts were located on the hill-side, and were about 80 ft. deep, and at some points the lower 60 ft. of this was ore-bearing ground. The walls and faces of the drift, as examined in the mine, consisted of breccia, composed



FIG. 163. Sketch of ore body trates the structure of the ore body. Over the drift the chert is more at the Spring City mines.

The ground is considered soft here, and is easily worked.

Drilling has been extended beneath this ore body and revealed the presence of chert down to a depth of 180 ft.; under this was another run of ore in harder ground, about 12 ft. thick.

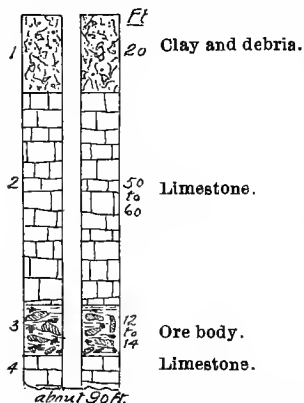


FIG. 164. Section of the Pump shaft.

of chert in blocks and disturbed layers surrounded by black mud, decomposed dolomite and a gray, earthy secondary chert through which blende and galena were disseminated, the former in much the greater quantity. The adjoining figure, from a sketch made in the mine, illna-

Shafts and drill-holes, closely adjoining the mine, passed through solid limestone, containing no chert, down to the depth of over 100 ft.; this shows a rapid change laterally in the character of the rock. At what is known as the Pump shaft, the adjoining section was passed through.

Part of the siliceous matrix is very light-colored, and is almost indistinguishable from the original chert of the country rock; in this white secondary chert there are at times disseminated small quantities of light-colored blende. Some barite has also been found associated with this ore. The blende is often well crystallized.

About $\frac{1}{2}$ mile east of these mines a considerable deposit of cerussite has recently been found.

The production of the Spring City mines, from January, 1893, to December 1, 1893, was as follows:

Lead ore	180 tons, sold for \$6,912
Zinc ore	1,181 " " 21,071

THE GALENA CAMP IN CHEROKEE COUNTY, KANSAS.

The extension of our observations to Galena, Kansas, and the description of the deposits there in this report, may appear to some as an unnecessary overstepping of the domain of a Geological Survey of Missouri, or as exhibiting a desire to appropriate to Missouri the possessions of a neighboring state. To an intelligent person familiar with the conditions of the case, the reasons for this extension will be very apparent. These lead and zinc deposits of Kansas are, in all their natural relations, a part of the Jasper county sub-district; to omit reference to them would be to leave out of consideration a very instructive series of bodies; conditions are to be seen here which are nowhere so well developed within the Missouri line, and which are calculated to throw much light on problems in which we are interested; moreover, the Galena camp covers only a few square miles, and its examination occupied little time and its description will require but little space.

This camp was first known as the Short creek mining district, from the name of the small creek, flowing just north of the town, westward into Spring river. Mr. Holibangh informs us that the first discovery of ore in this district was in

1868, in a well ; it attracted but little attention, and led to no further developments. Not until April, 1877, was the discovery made by two prospectors which immediately brought about the opening of the deposits. Since that time mining has been continuous, and the productions have been large. Statistics of production for the whole camp have already been given in chapter VI and on p. 546, and we will not repeat them here. The outputs of the different companies during recent years of operations are shown in the following tables, prepared from various sources of information :

PRODUCTIONS OF THE SOUTH SIDE MINING AND MANUFACTURING COMPANY.

From Company's books, by J. R. Holibaugh.

	Lead ore.	Values.	Zinc ore	Values.
	<i>Tons.</i>		<i>Tons.</i>	
1878	143	\$7,001	.....	.....
1879.....	5,146	233,331	136	\$2,169
1880.....	4,777	215,940	.....	.....
1881.....	3,852	220,518	1,142	18,268
1882.....	2,504	115,592	2,825	37,202
1883.....	1,184	69,693	1,763	28,206
1884.....	676	97,066	1,527	24,434
1885.....	641	31,169	4,114	65,822
1888.....	836	49,659	7,238	115,801
1887.....	902	47,458	5,051	80,814
1888.....	665	20,605	7,290	116,638
1889.....	952	43,810	8,689	107,025
1890.....	535	25,146	1,989	31,823
1891.....	508	25,781	4,229	67,667
1892.....	509	21,815	3,808	60,920
1893.....	785	29,728	1,291	18,079
Totals.....	24,615	1,253,703	48,592	764,568

PRODUCTIONS OF THE GALENA LEAD AND ZINC COMPANY.

From the Company's Books.

	Lead ore.	Zinc ore.		Lead ore	Zinc ore.
	<i>Tons.</i>	<i>Tons.</i>		<i>Tons.</i>	<i>Tons.</i>
1888.....	264	3,632	1892.....	1,127	2,787
1889.....	1,467	4,167	1893.....	3,328	1,408
1890.....	695	4,194	Totals	7,278	18,351
1891.....	397	2,163			

THE BATTLE-FIELD MINING COMPANY

From May 1, 1892, to Dec. 1, 1893, produced 1,155 tons lead ore and 6,547 tons zinc ore.

LEAD AND ZINC DEPOSITS OF MISSOURI.

TABLE OF PRODUCTIONS OF THE PRINCIPAL MINES OF GALENA, KAN., FOR 1890-91.

From reports of the State Mine Inspector.

	1890.		1891.	
	Lead ore.	Zinc ore.	Lead ore.	Zinc ore.
	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>	<i>Tons.</i>
Galena Lead and Zinc Mining Co	695	4,454	397	2,040
Southside Mining Co.....	546	1,989	702	3,577
Perry crusher	179	3,546		
James Murphy crusher No. 1	39	2,286		
Windsor Mining Co	484	608	200	1,125
Boice and Emmons crusher	66	1,336		
Murphy & Murphy	36	676	36	178
Illinois Lead and Zinc Co.....	63	926	76	1,206
Empire Mining Co.....	26	547	57	1,202
Vest & Co.....	128	363		
Templar Co.....	5	348		223
James Murphy crusher No. 2.....	26	494		
Conner & Brewster.....	214	1,140		
A. Cohen.....	5	117		
J. Brown Mining Co	151	98		
Moll, Weber and Co	111	212		
Fahlenbock, English & Co.....	4	199		
Gerilla Mining Co	36	119		
Pond & Stevenson.....	3	228		
Pond & Londerback	3	192		
Blaker Co	38	121		
Midland Co.....	3	188		250
Ohio Lead and Zinc Co.....	13	60	230	1,168
Maggie Taylor	64	50	100	422
Ol. Sprks	26	8	139	429
Central mine.....	38	1	215	477
Cornwall mine	3	7	57	205
Wysandotte mine	5	45	1	110
State Line mine.....		485		
Clement Mining Co			245	2,488
J. M. Cooper and Co.....			389	326
Queen Bee.....			12	278
Kansas Lead and Zinc Co.....			79	238
Annie Laurie.			53	212
Banner Mining Co.....				334
Enclid Co.....				1,125

The mines of this camp are confined to an area of about six square miles, lying principally between Short creek on the north and Shoal creek on the south, and extending less than three miles west of the state line. They are distributed over sections 13, 14, 15, 22, 23, 26, 27 and 28 of township 34 N., 25 E. of the sixth principal meridian, as shown on the district map. The principal mines are within the limits of the town of Galena. Southwest of this, in the breaks and along the tributaries of Short creek and Shoal creek, mines are also very thick. A few of these, examined by the writer, will serve as types for the whole camp.

The Weilup and Moll mines —These mines are situated in the SE $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 14, on the land of the Galena Lead and Zinc company. The shafts were about 50 feet deep, in a hard breccia. The fragments of the breccia were white chert, and the cementing material was principally a dark-colored and very hard and brittle secondary chert, which predominated greatly in quantity over the white original chert; associated with this matrix was also a considerable amount of soft, sandy material, which, on analysis, was found to be a calcareous sand, containing 85 per cent of silica (Anal. No. 379, p. 447); large deposits of tallow clay are also found in places, of both red and brown colors. No dolomite nor calcite were observed. Both galena and blende were found here, the former frequently in large crystals, in places partly decomposed and showing only a skeleton outline of the original forma.

In the Moll mine is a large and somewhat noted deposit of amorphous, white sulphide of zinc, already described by Mr. Robertson [210, p. 160]. This was found within a space about 30 ft. square or more, of varying thickness, and associated with tallow clay. It lay in a horizontal sheet, and, as exposed at one point, had evidently been deposited in a cavity which was in part still open. In this cavity, the white sulphide occupied the lower portion, and was overlain by tallow clay of yellow and brown colors, in horizontal layers. The total height of the opening was only a few feet, and the thickness of the white sulphide was between one and two feet. The results of an analysis of this material, made by the St. Louis Sampling and Testing works, is given in the description above referred to. This white sulphide has not been found in sufficient quantity for the question of its utilization to be of much importance; it cannot be collected when mixed with other materials by the ordinary processes of concentration. Small quantities have been sold for paint.

The Sawyer mine. —This mine is also on the land of the Galena Lead and Zinc company, in the SE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 14. The shaft is located less than a quarter of a mile south of those just described. The total depth was 121 ft. From the surface downward to a depth of 40 ft., an ore-bearing breccia of fractured chert was penetrated and was worked. Below this, the limestone country rock, more or less decomposed and associated with chert, was passed through. At the time of examination, operations were in progress at the bottom of the shaft, where 21 ft. of limestone, associated with a black chert, constituted the face of the drift. The limestone is decomposed in places to a soft sand; little or no dolomite was found, and no calcite was observed. The blende occurs in the limestone, both along the stratification planes and in seams transverse to these. No lead or pyrite was found in these lower workings.

The Martin and Hughes mine —This mine was located on what was known as the Schemerhorn land, in the SW. $\frac{1}{4}$ of section 23. The shaft was 80 ft. deep. The gangue consisted of dark or light-gray secondary chert, enclosing fragments of white original chert. This gangue was, in places, much decomposed and quite soft and friable. (Anal. Nos. 517, 518, p. 447.) The ore consisted principally of galena, which was in well-crystallized forma. A small amount of cerussite in crystals, associated with galena, was also noted. Comparatively little blende was observed. Small quantities of tallow clay make part of the gangue.

The Chenango Mines —These mines are located in the NW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 13, on the land of the South Side Mining and Manufacturing company. The shaft was 87 ft. deep. The ground seemed to be entirely brecciated, with no remnants of the original limestone left. Near the surface, yellowish white chert was passed through, and below this is the brecciated ore body. This breccia is made up of fragments of white chert, in hard, black secondary chert; throughout this are frequent clay pockets containing broken chert and clay. The white chert is extremely shattered and fragile in places. Between depths of 40 and 50 ft. galena was found, and large crystals of this mineral were obtained, partially decomposed and well coated with cerussite. At the

lower level, blends occurs almost exclusively in the matrix of the breccia. Sometimes the blends constitutes itself the entire matrix, and holds the fragments of white chert firmly together.

One of the most important and noteworthy features of the ore deposits of this camp is their great silicification and the remarkable development of the black secondary chert. Its presence makes the ground very hard, and working expensive and difficult in many places. It is frequently the most enduring portion of the body, and holds the lead and zinc minerals very tenaciously. On long exposure to the weather, these minerals are decomposed and removed so that we frequently find over the surface here, blocks and fragments of a honeycombed chert resembling some porphyritic volcanic rocks.

THE NEWTON COUNTY SUB-DISTRICT.

The Newton county sub-district of the Southwestern district lies immediately south of the Jasper county sub-district, and, with the exception of the Spring City mines, includes all the mines in Newton county south of township 27, and also those about Wentworth and Pioneer, just beyond the eastern line of the county. As in Jasper county, the rocks containing the ore deposits are exclusively Lower Carboniferous, with the same exceptions of certain limited patches of Coal Measure shales and sandstones which are often associated with the ores. The ore deposits are also, in a general way, similar to those of the Jasper county area. They differ, however, in that the individual bodies are not so large, and in that the ground is not generally so intensely brecciated and decomposed as is the case in Jasper county. Further, the oxidized ores are more abundant here, and the proportion of galena and blende is normally smaller. This is especially the case in the Granby

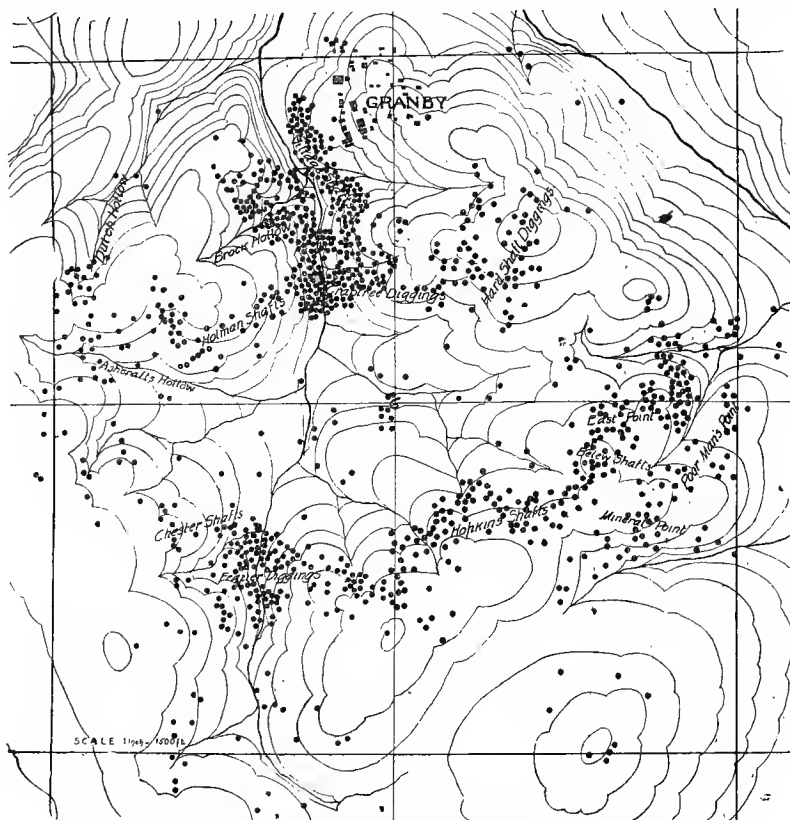


FIG. 165. Map showing density of mining at Granby and vicinity in 1873.
From A. Schmidt, Report 1873.

mines, where the carbonates and silicate constitute a large proportion of the output. The intensely siliceous ore body found at Wentworth, is nowhere duplicated in Jasper county; nor is, perhaps, so chemically pure a blende found there as is the yellow blende of that camp.

Within the limits above defined we recognize the following clusters of mines, which we term camps: The Granby, the Neosho or Moseley, the Dayton, the Seneca, the Wentworth and the Pioneer camps. Of these, the Granby camp is by far the most important. In addition, there are a few outlying diggings which can hardly be considered camps, or merit extended notice.

THE GRANBY CAMP.

The mines about Granby, as already stated, have been worked for nearly 40 years, and have been large producers. They were described briefly by Swallow in his Pacific railway report of 1858, and received full examination in 1872 and 1873 by the State Geological Survey. Mining was very active here about that time, and the whole country immediately about the town was honeycombed with diggings. An idea of the density of mining at that period may be gathered from the preceding cut, reproduced from a map accompanying the Survey report of 1873. It shows all shafts which had been open up to that time within the area represented. Since then, many more have been sunk, and the aggregate number is now legion. The majority of these were mere shallow, open pits, and only part of them were operated at any one time. Some, however, were quite deep and operated by machinery, and, during recent years, this has been more common, as mining extended to greater depths.

Detailed figures of production of this camp, extending over many years, could not be obtained. Mr. John P. Neville, president of the company, informs us, however, that during the past 25 years the production has averaged 1250 tons of lead ore and 6250 tons of zinc ore annually. The productions during recent years are shown in the following table:

PRODUCTIONS OF THE GRANBY MINING AND SMELTING CO.

	Lead ore.		Zinc ore.	
	Tons.	Values.	Tons.	Values.
1873 <i>a</i>	1,720	.....	.....	.....
1886 <i>b</i>	1,560	\$71,760	8,892	\$132,132
1899 <i>c</i>	1,417	56,680	5,987	119,740
1890 <i>c</i>	1,697	84,850	7,449	148,980
1891 <i>c</i>	805	36,225	5,458	87,336
1892 <i>c</i>	800	34,400	5,000	110,000
1893 <i>c</i>	1,111	44,457	5,268	63,220

a From Lloyd & Bauman [142].

b From John N. Wilson [242].

c From State Mine Inspector, years ending June 30.

Granby was visited by the writer and by Mr. Robertson several times, but at no time were many mines being worked. Attempt was made to examine a few typical deposits, and the following notes are the results:

The Woodcock and Turner mine.—This mine was situated on the southeastern edge of the town, near the top of the hill, at the head of a small ravine running west; it is about on the northern edge of what are designated as the Hard Shaft diggings, on the small map of the camp. The shaft was 75 ft. deep. The first 55 ft. were principally in a mass of loose chert and clay, while the next 15 ft. were in solid, bedded chert. Under this the run of ore was struck, and, as developed, was about 5 ft. high, 25 ft. wide, and followed an east to west direction. The metalliferous minerals were found near the top and bottom of this run, separated by alaba and blocks of chert. Large amounts of tallow clay occur, associated with the ore. Blende, galena and calamine are found in close association. The paragenesis of these minerals is in the order of galena, blende and calamine. Dolomite is quite abundant, and the ore body is particularly characterized by the prevalence of calcite crystals, which are found in the clay pockets in large scalenohedra. Pyromorphite also occurs in small quantities.

The Burnout mine.—This mine is situated about a quarter of a mile east of the last, down the hill-slope and about 40 ft. below it. Two runs of ore were recognized: one at a depth of about 65 ft., which rises toward the surface both to the north and south, up each side of the hollow; and one at a depth of 80 ft. Galena, with calcite, is found in the upper run, in a chert breccia; while, in the lower run, blende, calamine and calcite are found in disturbed layers of chert. Between these runs there was seen in the shaft a much decomposed limestone called sand, which forms the roof of the lower run.

The Cadmium mine.—This mine was examined by Mr. Robertson, and, as described by him, is located near the center of the SE. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 6, township 25 N., 30 W., in what are designated on the small map the Crabtree diggings. It was opened early in 1891, and was producing a large quantity of fine-grade ore in that year. The shaft was 50 feet deep, and penetrated broken flint and clay for nearly the whole distance. The ore was mainly blende, of a yellowish brown color and of fine quality. Some "silicate" was also found here. The ore body was a rudely lenticular shaped mass, whose width was not over 50 feet, the height 10 feet, so far as the developments had proceeded. Very little work had been done at the time of inspection. Besides blende, a little calamine was found in fine crystalline masses, often coated with greenockite. Calcite crystals coated with the same substance also occurred. The blende carried considerable cadmium.

The country rock is composed of limestone and chert interstratified, with more or less of the limestone dissolved and removed. That which does remain is often converted into dolomite in the vicinity of the ore, fine-grained, hard, compact, and locally termed "sand rock," although good crystals of dolomite frequently occur.

The Butler mine.—This mine is located about a mile southwest of the town, in the upland prairie in the eastern part of section 12. When examined by Mr. Robertson in 1891, a shaft was sunk 50 feet in depth, and passed through a series of layers of limestone and chert until it reached the first opening at 50 feet. This opening was 5 to 8 feet high and was opened by a drift, which gradually widened away from the shaft, until a 40-foot face of ore was exhibited. The ore was composed of galena, filling seams and crevices in the broken chert. It was interbedded between the limestone (here dolomized) and chert layers. About 10 feet below was a second opening, of about three feet in height, in which large quantities of "silicate" were found.

Galena and calamine are the principal minerals. The calamine occurs in clusters of very delicate crystals, and some beautiful specimens have been obtained from this mine.

The country rock is the usual Lower Carboniferous limestone, with more or less chert. In and around the ore body, much of the limestone has been removed, and that which remains, in close vicinity of the ore, is altered to dolomite, becoming softer, darker, and having a decidedly different appearance from the ordinary limestone rock of the region.

Elsewhere, over this upland prairie, are numerous diggings.

The Davis mine is one of considerable importance, and from which a large quantity of ore was obtained. It is about one mile southwest of the last described. A large cave-in now exposes the brecciated ore body, which is seen to be composed of fragments of chert, cemented by a dark secondary chert containing blende and iridescent galena.

Inasmuch as so little opportunity is now afforded for observation of the ground developed by the older workings, it seems advisable to include here, for the sake of completeness, some notes from the earlier reports. We hence add the following brief abstracts from Swallow's and Schmidt's descriptions of the Granby mine.

In the Pacific railway report of 1858, Swallow describes the lead ore here as occurring in somewhat regular leads, or as disseminated through beds of chert, clay, sand and limestone, which overlie the Lower Carboniferous formation; also as occurring in crevices and cavities of the limestone and, very frequently disseminated in greater or less quantity through regular crystalline beds of limestone. Galena was then the most abundant ore, and was often excavated in large masses; some cerussite and some anglesite were also found.

In the report of 1873, Schmidt gives detailed descriptions of the different diggings designated on the map on page 601.

Village diggings consisted of about 120 shafts, of which only 7 were in operation. The shaft passed first through a variable thickness of broken chert, surrounded by sand or clay, overlying beds of chert which, in places, alternated with beds of limestone; under this, limestone was encountered, decomposed and sandy near the surface, dense and gray below. Two openings or runs were worked, the upper in the chert layers, the lower in the limestone. In these openings the galena was found between slabs of chert, along with calamine, dolomite and tallow clay; but the contents were very variable. The galena was generally above the calamine; calcite was also found. The occurrence of cerussite and pyromorphite in amorphous masses, and in crystals, cemented in brown, hard, siliceous clay, is noted as remarkable. The figures of the opposite page show the conditions of occurrence as illustrated by Schmidt.

In the Brock Hollow diggings, there were 131 shafts, but only 3 operating. Most of the mining was in the open, surface material.

In the Crabtree diggings, there were 90 shafts, and 11 operating. Two openings were worked, as in the Village diggings. They sloped toward the surface to the south and east.

At the Holman diggings, 160 shafts were sunk, of which 9 were being worked at the time of inspection. Two openings were followed, in which the ore was found in limestone and between limestone and chert beds. Both galena and calamine were found associated with dolomite and calcite, all bedded in tallow clay.

In the Hard Shaft diggings, an upper opening, 2 ft. deep, was worked, running through beds of limestone and chert; it contained broken chert, red clay and galena. The lower opening, 8 ft. high, was also in limestone and chert, and contained dolomite and pockets of tallow clay; layers of white smithsonite and calamine were found here, and, in one shaft, galena occurred beneath sheets of calamine, which is an exceptional condition.

In the Frazier and Chester diggings, 180 shafts were recognized, of which 7 were then working. Two openings were followed, the upper, in red clay and galena under porous chert; the lower, 10 ft. high, in chert beds, and containing calamine in thin broken slabs, with red tallow clay and sand; in one shaft, blocks of decomposed limestone were found; smithsonite, cerussite, decomposed dolomite and galena in pockets and streaks and crystals, were all found in these workings, frequently in large bunches; the ground was very variable, however.

On the East fork, many shafts were sunk, and 2 runs of ore were operated of a similar nature to the ones already described.

At the Bellevue shaft, galena was found in the upper workings, and, in the lower, patches of blende and galena associated with nearly black calamine.

In the Hopkins shaft, openings were found between chert layers containing red clay, broken chert and galena; under this was 2 to 3 ft. of calamine, frequently in horizontal seams with bunches of galena and blende.

At Minerel Point and Poor Man's diggings, 60 shafts were counted, of which 2 were working. A number of runs of ore in chert were followed, containing red clay and sand with loose galena and calamine.

In conclusion, Schmidt states that, so far as known, all of the ore deposits of the immediate vicinity of Granby are confined to a zone, rarely thicker than 10 ft., lying immediately above the solid limestone, and consisting of altered and more or less broken formations. The great horizontal extent of this zone he considers, however, as an offset to its limited vertical dimensions. How he reconciles this statement with the fact repeatedly described by him, of the existence of

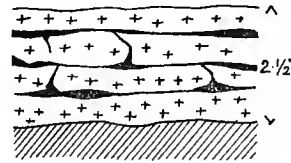


Fig. 14

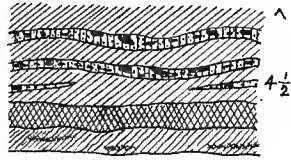


Fig. 15

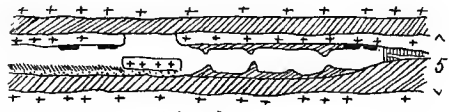


Fig. 13.

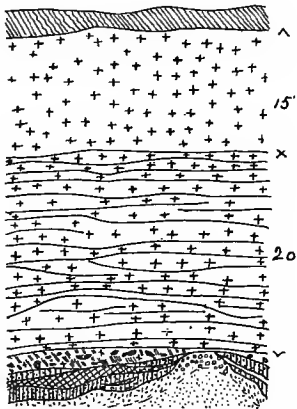


Fig. 18.

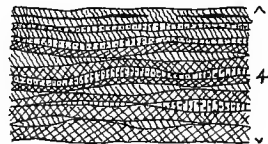


Fig. 21

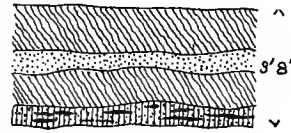


Fig. 22

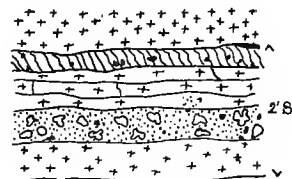
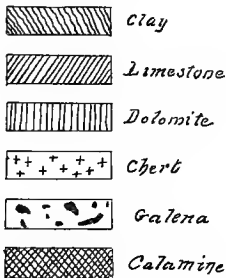


Fig. 28.

FIG. 166. Sketches of occurrence of ore at Granby.
From A. Schmidt, Rept. 1873-'74.

several runs of ore at different levels and separated by more than 10 ft., is not stated; he presumably refers only to the lowermost and the then most productive deposits. Recent developments and our own observation do not show that the ore bodies are confined to any one horizon.

In the country about Granby are a number of outlying deposits also referred to by Schmidt.

Prairie diggings, two miles southwest of the town, are the same as the Davis mines above referred to. Schmidt describes the ore as being found in a depression, in gray oölitic limestone, the body consisting of broken chert with red clay and blocks of sandy limestone; between the latter, or in the red clay, the galena was found in thin sheets; siliceous cerussite, calamine and some pyromorphite were also found in the clay. The shafts were 30 to 40 ft. deep in this ore body, while solid limestone was struck close to the surface, near the margin of the depression. Outcrops of red sandstone of probable Coal Measure age are noted south of the mine.

The Hen diggings were two miles west of Granby, in the SE. $\frac{1}{4}$ section 2, township 25 N., 31 W. Thirty or forty shafts had been sunk to depths of about 25 ft. through broken slabs of chert and breccia, the fragments of which latter were cemented by white "quartzite" or hard clay, in which the galena was found. Solid limestone underlay this breccia. Red and yellow sandstone is found on the hill-slopes.

The Culpeper diggings were in sections 1 and 2, township 25 N., 30 W., about 5 miles east of Granby. Galena was found in broken chert, overlying the limestone country rock, and also in small crevices, with dolomite and red clay in the limestone. Sandstone is exposed on higher ground, underlain by gray and oölitic limestone.

THE NEOSHO OR MOSELY CAMP.

The principal mining about Neosho has been at the Mosely mines, which include a number of diggings in sections 26, 27 and 35, near where these sections corner. Swallow describes these as the most systematically conducted mines in the southwest in 1854. Large shafts and drifts were sunk in the side of a bluff of limestone, but the mining was entirely in a chert conglomerate, in which were masses of red and white clay containing galena and cerussite. Schmidt describes these diggings in 1873 as consisting of shafts sunk through surface clay and broken chert, in which were included rounded and altered masses of dark gray limestone; between these, at depths of 45 to 50 ft., were irregular seams or elongated pockets of lead and zinc ore; the galena occurred in thin sheets in soft dolomite, and also in the form of crystals adhering to chert or loose in the clay; calamine occurred, enclosing galena or blende, buried in dolomite or red clay.

Operations at these mines have been of an intermittent nature, and, at the time of visit, they were not open for examination. During the last year or two work has been started there again, and quite a large amount of ore has been taken out. The following figures illustrate the rate at which the mines have produced at different periods:

	Lead ore.		Zinc ore.	
	Tons.	Values.	Tons.	Values.
1850-1854 Mosely mines	231			
1836 Moseley mines.....	25	\$1,200	1,500	\$13,000
1889 Moseley mines operating				
1893a Moseley Zinc Co.....	100	4,400	2,000	30,000

a From State Mine Inspector's report, year ending June 30.

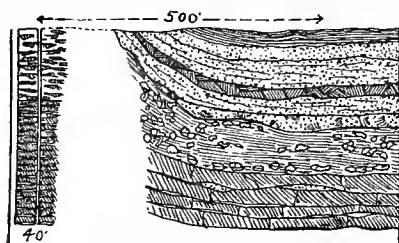
Close to the town of Neosho there are no mines at present. A little galena has been found in the limestone so abundantly exposed there, and also in the overlying clay and chert. Southeast of the town, there were formerly small diggings in clay

and broken chert. About four miles north of the town are what are known as the Neosho mines. Mining here was on a limited scale, and no descriptions of the deposits have been obtained.

THE DAYTON CAMP.

Northwest of Dayton, for a distance of about five miles, are several groups of mines on Spurgeon's prairie, some of which have been worked for many years. Among these are included the Spurgeon, Henderson, Shaffer, Wainwright & Newman, and Buzzard mines. About three miles northwest of Dayton is a small patch of diggings known as the Indianapolis mines.

The Conley diggings, as described by Schmidt, were in sections 31 and 32, township 26 N., 32 W., near the Spurgeon mines. The shafts were about 20 feet deep, and



- Ft.
 3 Soil.
 2 Yellow sand or black clay.
 6 Sandstone.
 3 Greenish clay.
 4 Sandstone.
 4 Sandstone and red tal-low clay.
 10 Limestone, hard, broken and shaly.

Broken chert layers.

galena was found loose in the clay; one shaft penetrated 15 feet of clay containing cerussite, and under this, 95 feet of broken chert in clay and sand; no solid limestone was reached at the bottom. In another shaft, 25 feet deep, blende was found in the clay between the chert fragments, and also in a dark-gray, spongy secondary chert.

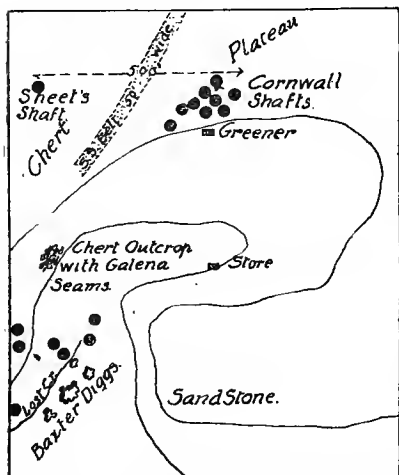


FIG. 167. Map and section of the Cornwall diggings.
 From A. Schmidt, Rept. 1873-74.

the clay, large pieces of galena were frequently found. In the broken limestone beneath, the fragments were surrounded by clay which contained galena, cerussite and calamine; more or less bitumen was also found in the limestone.

The Baxter diggings were in section 1, township 25 N., 33 W., and occupied the ground of the present Henderson mines. Shafts were sunk here through masses of broken chert, associated with limestone blocks and surrounded by red clay. Galena occurred in seams and crystals between layers of chert, and also in limestone. At the Carpenter mines, in the adjoining section 2, shafts penetrated white sandstone underlain by clay, broken limestone and layers of chert and limestone. The limestone of the layers between the chert was dark and granular, and contained bitumen and crystals of galena and blende.

The Cornwall diggings were in section 36, township 26 N., 33 W. Their location and a section through the mine are shown on the adjoining cut, reproduced from Schmidt. Shafts were sunk through sandstones and clays and shaly limestone, which are evidently Coal Measure rocks, lying in a limited basin, as indicated in the section. The sandstone contained some galena, in specks and seams between the layers, which latter were more or less broken; in

During recent years, mining over this area has been conducted at intervals. The following table will give an idea of the extent of operations at different dates:

PRODUCTIONS OF THE DAYTON CAMP.

		Lead ore.		Zinc ore.	
		Tons.	Values.	Tons.	Values.
1889	Henderson mine } operating.				
	Shipley mine }				
1890	Potwin mine (operating)				
1891a	Henderson mine	12	\$650	96	\$2,151
	Spurgeon mine	2½	42		
	Wainwright & Newman	25	1,200	50	1,100
1892a	Henderson mine	25	1,150	40	952

a From State Mine Inspector's reports, years ending June 30.

THE SENECA CAMP.

Mining in the vicinity of Seneca is of comparatively recent date, though the Sibley mine in section 8, township 24 N., 34 W., about two miles southwest of Seneca, was worked some 20 years ago, and is described by Schmidt. Shallow shafts here penetrated red and yellow, sandy clay, containing fragments and slabs of gray chert. Lower down, chert fragments and blocks of yellow sandy limestone were encountered, the latter enclosing chert breccia with crystals or masses of galena; under this, soft, white chert was found; at one locality thin sheets of galena occurred in sandy clay.

Near the town of Seneca, mines opened during the past few years were visited by Mr. Robertson in 1891. The conditions of the workings and the character of the ore deposits are described by him as follows:

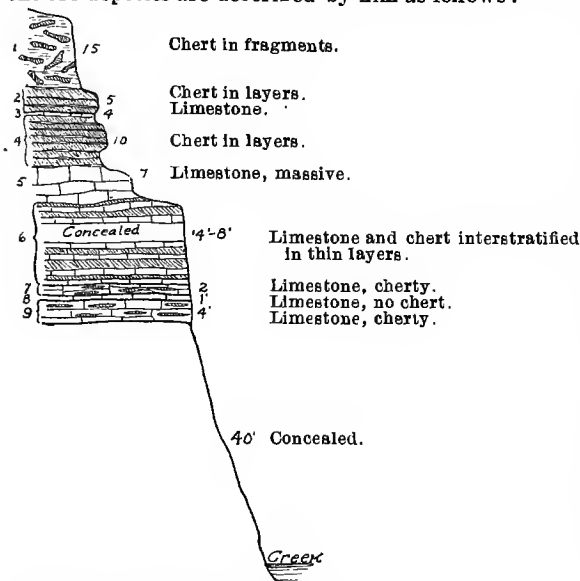


FIG. 168. Section on Little Lost creek.

Potwin and Holmes.—These parties controlled a tract in the N. ½ of section 8, township 24 N., 34 W., about one and one-half miles southwest of Seneca, on the St. Louis & San Francisco railway. The mine was opened in 1889 by Mr. Thos. Reeves of Seneca. About half a mile north-east of the mine, a section was measured on Little Lost creek which will serve to show the nature of the strata in which the ores occur at this point. This section shows very clearly the way the limestone and chert are interstratified, and it will be readily seen how the removal of all or part of the limestone by solution will allow the chert layers to settle and fracture, thus forming the thick deposits of broken chert in which the ore so frequently occurs.

The ore of the mine is entirely galena, occurring between beds of broken chert, in an impure limestone of a decided yellow color.

The main shaft was sunk on a distinct crevice, which runs N. 30° E., and this was followed to a depth of 138 feet. At a depth of 50 feet the horizontal run of ore was struck, which followed the direction of the crevice; its thickness was about 6-10 feet and its width not more than 20 feet. The ore is stoped out very irregularly, thus leaving the workings in a somewhat peculiar shape. No accessory minerals were noticed, except carbonates of lead as an occasional incrustation on galena. The chert found in the neighborhood is often altered, the horizontal structure being much obscured by the process.

During 1891, about 550 tons of lead ore were produced; the mine is since closed by litigation.

The Seneca Lead and Zinc Company.—This company was mining in the S. W. $\frac{1}{4}$ of section 36, township 25 N., 34 W.

Two shafts had been sunk to a depth of 130 feet. Only one was in operation at the time of inspection. Here the ore, as in Potwin & Holmes mine, was nearly all galena, but a small amount of "silicate" was found near the roof in the south end. The galena occurs, very much as in mine just described, between broken, horizontal layers of chert, in a more or less impure yellow limestone. The ore body is in the shape of a run, its length being about 250 feet, its width 20 to 40 feet, and its height, in places, as much as 30 feet. These dimensions, however, only indicate the space in which the ore breccia occurred. It is not to be supposed that merchantable ore filled all of this. The drifts and the ore body, at a depth of 100 feet, ran along a well-defined crevice and extended from the shaft about 60 feet N. 30° E. and about 90 feet S. 40° W.

Galena was the principal mineral noted. Some pyrite or marcasite was found, cementing chert fragments. A variety of barite, translucent and of an amber yellow color, much resembling calcite, also occurs here.

The amounts produced by these mines during recent years may be estimated from the following figures. The Potwin mine was worked during preceding years, but we have been unable to obtain the output:

	Lead ore.		Zinc ore.	
	Tons.	Values.	Tons.	Values.
1891 α Potwin mine	553	\$27,655	1 $\frac{1}{2}$	\$16
Seneca Lead and Zinc Co.			23	299
1892 α Seneca Lead and Zinc Co.	20	900	160	1,740

α State Mine Inspector's reports, years ending June 30.

THE WENTWORTH CAMP.

Wentworth is situated in the northeastern corner of Newton county, and the mines, which have been opened there since 1889, are practically new developments in a section of the county in which no mining had been done before. Since this recent discovery, prospecting and shafting has been quite actively pursued just south of the little town of Wentworth, and a number of deposits have been discovered. Up to date, however, not very much ore has been produced. The principal developments are those of the Peirce City Mining company, of Purdy & Jones, the Molly Gibson, the Little Nugget M. company, and the Gobbler mine. In the country about Wentworth, a few other shafts have been sunk, but without developing any large body of ore. The principal of these are the Conway mines, about four miles southwest of Wentworth. The only outputs quoted in the State Mine Inspector's reports from this camp are the following, for the years ending June 30:

PRODUCTIONS WENTWORTH MINE.

	Lead ore.		Zinc ore.	
	Tons.	Values.	Tons.	Values.
1891 Peirce City M. Co			72	\$1,368
1892 Peirce M. Co.....			313	7,370
1893 Little Nugget M. Co.....			290	5,510

The Gobbler shaft.—This shaft is situated a few hundred feet northeast of the center of section 11, township 25 N., 29 W. At the time of inspection it was 95 ft. deep. The lower 30 ft. consisted of brecciated white chert, with traces of a stratified arrangement preserved, cemented by a black secondary chert and a little blende, the whole constituting a very hard mass. A few small pockets of tallow clay occur, however, though not in sufficient abundance to make the ground open. Of mineralogical interest is the occurrence of crystallized quartz. Most of the blende is found near the top and bottom of this ore-bearing breccia. Over this, is 40 ft. of solid, white and dark chert, in wavy layers, containing some blende.

The Purdy & Jones shaft.—This shaft is about half a mile east of the last, just across the county line, and is thus in Lawrence county. It is on the middle of the western line of the SW. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 12, township 25 N., 28 W., just south of the St. Louis & San Francisco railway track.

At the time of visit, the shaft was 107 ft. deep, and the section of figure 169 was observed.

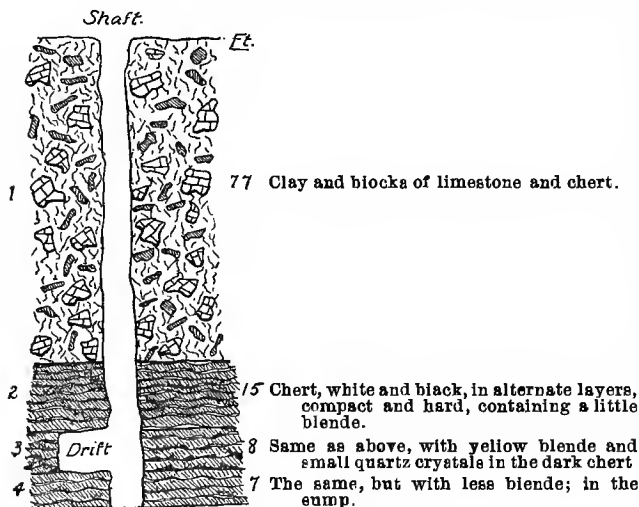


FIG. 169. Section of the Purdy & Jones shaft.

of mines, known as Dye's camp; and north of these about six miles, in section 12, township 27 N., 30 W., were the Perry diggings, described by Schmidt in the report of 1873. Several shafts were sunk here, and galena was found in seams and specks in layers of undisturbed limestone and chert, the former bituminous. Calamine was found in loose masses in the sand and clay, overlying the solid rock.

This ore body, or "ground," as it is called, is exceedingly hard, contains little or no clay and the chert is not fractured; no calcite or dolomite were observed, and no pyrite or other accessories were found. Some calamine occurs in the upper diggings.

Since the time of visit, mining has continued here, operations have been very much extended and long faces of ore are now exposed. The ground continues excessively hard, however, which is the chief obstacle to mining.

West of Wentworth, about six miles, is a bunch

THE PIONEER CAMP.

This camp is situated in Barry county, south and north of the little postoffice of Pioneer, just beyond the Newton county line, about ten miles south of Peirce City and about eight miles west of Purdy. Lead ore had been found here many years back, but active developments did not begin until early in the year 1891. The productions for 1892 are given by the State Mine Inspector as follows:

PRODUCTIONS PIONEER CAMP.

	Lead ore.		Zinc ore.	
	Tons.	Values.	Tons.	Values.
1891 Shafts being sunk for development, no ore shipped.				
1892 ^a Allen & Stark			40	\$1,000
Ft. Smith M. & S Co. (Northcutt) ..	84	\$3,865	102	988

^a Year ending June 30.

These mines were visited by Mr. Robertson in the summer of 1891, and are described by him as follows:

Northcutt Land—This mine is in section 3, township 24 N., 29 W., about 12 miles south of Peirce City, to which place the ore is hauled and shipped. Lead has been found in this vicinity in the streama for many years. In January, 1891, Messrs. Allen, Lampkin & Hutchins put down a shaft about 20 feet deep. This penetrated the Lower Carboniferous limestone, and at the bottom heavy chert beds appeared. The ore consisted of blende and galena, which occurred in lenticular sheets along the stratification planes, extending into the joint planes, and also in disconnected masses, as is illustrated in figure 170. The galena occurred in masses 9 inches in diameter and less. The ore had not been followed by drifting at the time of the visit and was confined to the lower portion of the shaft.

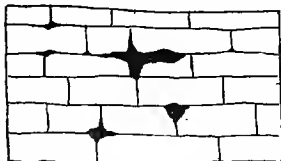


FIG. 170. Occurrence of ore at the Northcutt mine.

The limestone is changed to dolomite in the vicinity of the ore, at times in beautiful crystals. There had been about 2 tons of blende and 2 tons of galena taken out of this ground, at the date of examination; since then, up to 1893, Mr. Marriot of Purdy reports that 100 tons of lead and zinc ore have been produced.

Allen & Stark.—This mine is in the SE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 25, township 25 N., 29 W., on the top of a bluff about 150 feet high, overlooking Shoal creek. A deposit of calamine, intermingled with much broken original chert, and all cemented together by a light grey compact secondary chert was seen. Ten or fifteen tons of the silicate had been blasted out and laid on the dump at the time of inspection; no work was then in progress here.

In the NW. $\frac{1}{4}$, SW. $\frac{1}{4}$ section 24, township 25 N., 29 W., the same parties were engaged in opening a promising prospect. The deposit lay on the side of a hill, in the Lower Carboniferous limestone, here carrying considerable chert. The ore was entirely blende, of a light yellow color, and good quality. It occurred in broken chert, the whole being cemented together by a dark chocolate-colored secondary chert, very hard and tough, having the appearance of a mosaic. The mine was opened by means of a shaft about 30 feet deep. The heavily bedded chert was not noticed, the walls of the shaft being composed mainly of the light-colored, brittle chert of the Burlington limestone. Since visiting this locality, it is reported that a drift of 40 feet has been run into the hill and from the end of that a winze 30 ft. in depth has been sunk, and that the appearances are favorable. Up to the end of 1893, Mr. Marriot reports the output of this mine as 50 tons of zinc ore.

On the Feney land, in the SW. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 3, township 24 N., 29 W., is a prospect in the bluff, on the side of the creek, that resembled that of the Morton land below.

Claycomb, Jones & Hailey, of Cassville, started a prospect in the NW. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 10, township 24 N., 29 W. Here the ore seemed to lie in the lower part of the Burlington limestone, in the broken chert. It is mainly composed of "silicate," which appeared in considerable quantity. A portion of the bluff was composed of a breccia of chert and ore. A shaft about 20 feet in depth was sunk here, at the mouth of which some six or eight tons of ore were piled up.

On the Morton land, in the NW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 10, township 24 N., 29 W., in the bluff along the side of the stream, some very fine-looking "silicate" was seen. Several tons had been taken out. The ore was imbedded between the layers of the heavy chert which lies beneath the massive limestone.

About 10 miles northwest of Pioneer, around the postoffice at Newtonia, a number of diggings were begun in 1891, and in 1892 and 1893 silicate of zinc and galena was mined. The K. D. F. Mining company here produced about 7 tons of lead ore and 100 tons of zinc ore in those two years. About one and a half miles southeast of Ritchie, prospecting was carried on about this time. This locality is not credited with a shipment of ore, and it is not probable that any considerable quantity was produced.

THE LAWRENCE AND BARRY COUNTY SUB-DISTRICT.

This sub-district covers all of Lawrence county, and in addition, townships 25 and 26 N., ranges 24, 25, 26 and 27 W., these lying mostly in Barry county, but also including 72 square miles of Stone county.

The rocks exposed at the surface are Lower Carboniferous limestones and cherts, with the exception of a few sections of magnesian limestones of Lower Silurian age along the southern border, and certain limited patches of Coal Measure shale, sandstone and conglomerate, which are encountered at a number of points and cover, in the aggregate, a considerable area. These rocks are normally in a horizontal position. Thus the stratigraphy of the sub-district is, in general, similar to that of Jasper and Newton counties.

The large deposits of lead and zinc ore in this area were not known until within a comparatively recent time. The occurrence of lead has, however, been known for a much longer period. In 1869, Mr. O. P. Johnson, while prospecting, discovered lead northeast of Mount Vernon about 5 miles. In 1873, Messrs. Geo. Haley and Geo. Conwell prospected and worked a small residuary deposit of lead ore on the Jenkins road, about 6 miles from Mount Vernon.

The only mining camp of magnitude is at Aurora; but lately mines have been opened about 10 miles west of Mount Vernon, which are of a promising nature;

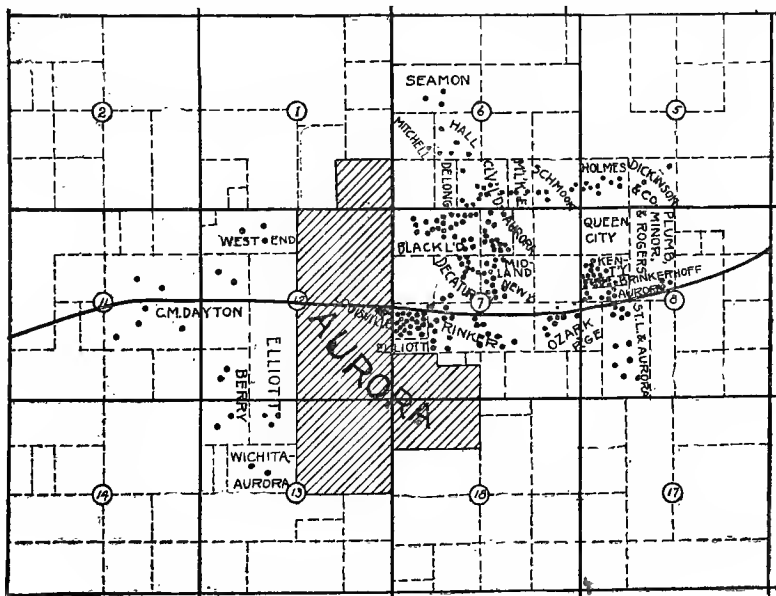


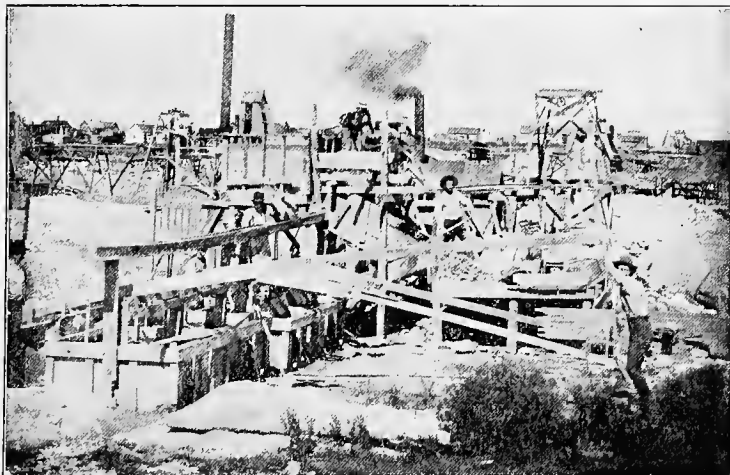
FIG 171. Map of mining properties in the vicinity of Aurora.
From map of W. W. Van Frank, C. E.

and, further, a group of mines a few miles east of Purdy, in Barry county, have produced a considerable amount of ore during recent years. In addition to these, there are a number of isolated diggings scattered over the sub-district, as is shown on the map.

FIG. 1.



FIG. 2.



MINING IN SOUTHWESTERN MISSOURI.

FIG. 1. VIEW OF A MINING CAMP NEAR AURORA.

FIG. 2. VIEW OF HAND JIGS.

From photographs by W. P. Jenney.

The productions of this camp we are fortunately able to give with completeness, because of the comparatively recent date at which operations were begun. In the preceding statistical chapter we have already given the total figures for the county. To these we now add, from data kindly furnished by Messrs. Plumb and Minor, the totals by companies, on the next page.

MINES OF THE BLACK LAND.

This land comprises the NW. $\frac{1}{4}$ of the NW. $\frac{1}{4}$, and the NE. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 7. It was one of the tracts earliest opened, and has proven one of the most profitable. On it, the Rolla, Osborne, Lead Queen, McLeod, Saavely, Allen, Hall, Frye, and other prominent mines are situated. These shafts operate a body of ore running across the Black land, near its northern line, as is shown on the map opposite this page. The workings connect with those of other shafts on this tract, as well as with those of the Cleveland and Aurora Lead and Zinc company's land to the east.

The Allen shaft.—This shaft, at the time when last visited, in December, 1893, was 120 ft. deep. Immediately opposite, about 150 ft. to the north, was the McLeod shaft, 70 to 80 ft. deep. A cross-

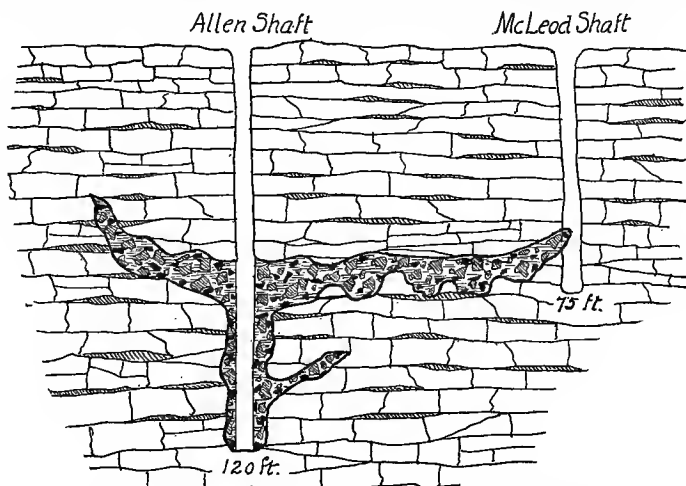


FIG. 173. Cross-section through the Allen and McLeod shafts.

section through these two shafts is introduced, and shows how they are connected and the position of the ore body. Both shafts passed, first, through solid limestone, from 50 to 60 feet thick. Under this, the basin-shaped ore body was struck; it rises on both sides toward the surface, and tapers out at the same time. The country rock consists of limestone and chert beds, which are horizontal and undisturbed. Close to the shaft, a deep pocket or extension of the ore body was followed to a depth of 120 ft., as is shown in the cross-section; this was not of the nature of a crevice, but more

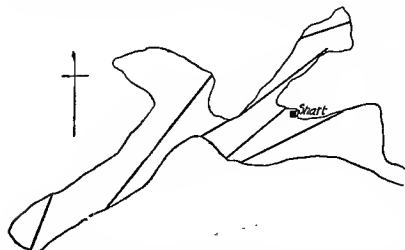


FIG. 174. Joint-planes in the Allen mine
From sketch by W. W. Van Frank, C. E.

of an elongated sack or pocket, and was not traceable upward in the shaft, above the main body of ore. This channel-like deposit extends in a direction a little north of east, in conformity with the general trend shown in figure 172. The face of ore is from 3 to 10 feet high; it is underlain and overlain by limestone. The surface of the limestone is very irregular, especially in the foot-wall, where hummocks and ridges or bars separate depressions which contain large pockets of ore; on the sides of the basin, the ore body cuts diagonally across the strata at an angle of sometimes as much as 20° with

LEAD AND ZINC DEPOSITS OF MISSOURI.

PRODUCTIONS OF AURORA MINES.

	1890.				1891.				1892.				1898.			
	Gallena	Blende Silicate	Total values.		Gallena	Blende Silicate	Total values		Gallena	Blende Silicate	Total values.		Gallena	Blende Silicate	Total values.	
	Tons.	Tons.			Tons.	Tons.			Tons.	Tons.			Tons.	Tons.		
Anvora M. Co.....						1,826	\$27,842	7	2,814	141	\$85,082		570	2,134	3,126	\$124,846
Berry M. Co.....					81		4,038	90		51	3,911		38		45	2,056
Black land.....	2,301	8	\$114,488		176		90,106	1,219		741	71,266		729	22	334	34,349
Bonanza M. Co.....	950		20,285													
Brinkerhoff M. Co ..	11	232	9	5,699	48	535	121	14,242	1	741						
Campbell M. Co....																
Dayton M. Co.....	145		7,791		200		10,487	159					51	515	129	12,236
Deocrat M. Co.....	286		38,199		214		13,864	139		63	17,084		63		11	1,737
DeLong M. Co.....								44			1,976					
Elliot M. Co.....					63		3,000	61		161	3,615		71		151	3,835
Hall M. Co.....					3		132	31			1,418					
Holmes M. Co.....								1	42	102	2,610					
Kentucky M. Co....	189	86	19,532		95	870	44,336	292	430	1,037	35,758		459	985	282	37,895
Lille's land.....	100	448	50,000		270	738	47,692	163	310	381	20,226		189	3,410	760	12,126
Louisville M. Co	170	68	35,644		175	48	1,880	26,553	105	2	731	15,524	358	7	286	16,332
Midland M. Co.....	42	11	10,143		19		418	6,388	52		313	6,405	38		130	2,345
Missouri M. Co.....					61	20	1,139	17,489	25	142	819	14,245				
Nevada M. Co.....											500					
New York M. Co....		10	76	1,402	2	180	149									
Ozark M. Co.....		121	321	7,427	1	271	14		55	15	2,089					
Pinnab, Minor & Rogers								2	4	1	286			17		521
Rinker land.....			2,719	86,155	84	9	3,368						152	13	1,043	17,610

Rinker, Geo. W.	41	110	236	7,112	243	626	1,250	37,949	288	40	178	2,723
St. Louis-Aurora Co.					532	635	2,019	73,273	458	309	93	17,956
Schmook land					45			2,124		866	3,456	82,723
Seamon M. Co.	235			11,181	402	77	175	21,423				
Stewart M. Co.					9		17	704				
Stewart, P. W.									165	1,294	2,944	65,124
Terre Haute land												
Vance land	451	8	135	58,649	419	237	591	36,354				
Sundry	311	15	45	8,322					177	31	55	6,905
Totals	4,003	4,300	11,380	439,439	4,081	5,665	8,764	445,757	3,837	10,260	13,078	453,925

the horizontal. The ore body is soft in places, consisting of chert fragments surrounded by clay; elsewhere it is hard, and is composed of blocks and layers of chert and limestone, the latter partially decomposed. The metalliferous minerals are chiefly galena, with a little blende and silicate in the lowest levels. The galena is generally near the top or bottom of the run, with limestone blocks between. Tallow clay and calcite also occur here; but very little pyrite, and no dolomite, were observed. Joint-planes were seen running diagonally across the deposit, in a northeast to southwest direction; a few also ran from north to south. Figure 174 illustrates their distribution in one part of the Allen mine.

The Rolla Mining Company (R).—This company was one of the oldest in the vicinity. It was composed mainly of residents of the town of Rolla. The mine operated is less than a fourth of a mile NE. of the last, and is described as follows by Mr. Robertson:

"The mine is in the prevailing limestone of this district, here quite coarsely crystalline, and carrying less interstratified chert than is common. The ore is almost entirely galena, occurring interbedded in the limestone, and at times partially filling the space left by the removal of that rock. The ore body appeared to be a run, having sometimes a vertical thickness of 20 to 30 feet, and a horizontal width as great as 100 feet. It has been followed in a direction a little north of east and south of west to the limits of the lot, or about 200 feet, but had been developed in lots adjoining to the east and west for over 1200 feet. While more or less of the ore occurred interbedded throughout the whole ore body, by far the largest part had been taken from abnormally developed portions resembling caves or pockets. Galena was the only mineral noticed. It occurred in the clay, often well crystallized, and always in modifications of the octahedron.

The Osborne, Ely and other mines occur on this property, and are similar to the Rolla in all respects, excepting, perhaps, in production. In the Osborne and Allen, particularly, E. and W. crevices were well developed, and the ore bodies occurred along their courses."

CLEVELAND AND AURORA MINING CO. (R)

These mines were also examined by Mr. Robertson, and he gives the following description. The company's land lies just northeast of the Black land, but considerable zinc ore, both blende and silicate, was found here. The principal mines are the Reynolda, Nathan, Goodwin and Wilson. Of these, the Reynolda mine, lying immediately north of the Rolla, is apparently a continuation of it, and is in every way similar to it.

"Nathan Mine.—This mine was started in the spring of 1891. It was the property of E. Nathan of Aurora. The mine is situated in the same horizon as the Rolla, and the ore body was about 60 ft. beneath the surface. The ore consisted largely of galena, though much blende and sili-

cate were also found. The ore body had a direction N., 30 E., was about 80 ft. in thickness, and had not been explored for its full width. Along its course it had been opened in Goodwin's and Wilson's shafts adjoining, and developed for about 500 feet.

The galena invariably occurred near the top, and lay rudely interbedded between limestone and chert strata, and also with broken chert, as did also the blende. It was accompanied by a gangue of broken chert, soft, decomposed, earthy limestone and joint-clay. The 'silicate,' evidently of secondary formation, spread over and cemented the broken chert and coated it in cavities. Galena occurred rarely in good crystals, but generally in crystalline masses. The blende was of fine quality and of a bright yellowish brown color; it was seldom crystallized. The 'silicate' is often noticed coating the blende and cementing the fragments."

The occurrence of ore in the Goodwin and Wilson mines is identical with that in the Nathan mine; hence, they are not described here in detail.

From these mines, which are in the northwestern corner of the camp, there extends a long string of shafts for a distance of over a mile in an ENE. direction. The workings of many of these are actually connected under-ground, and they all undoubtedly belong to one long deposit of basin-like form, as described. Though we were unable to examine more than one other of this series, we are informed by Mr. Van Frank, who is thoroughly familiar with the ground, that this basin-like shape is characteristic of the deposit throughout.

THE ORIENTAL MINE.

This mine is a recent development, and was visited in December, 1893. The shaft was then 128 ft. deep, and passed through the following section:

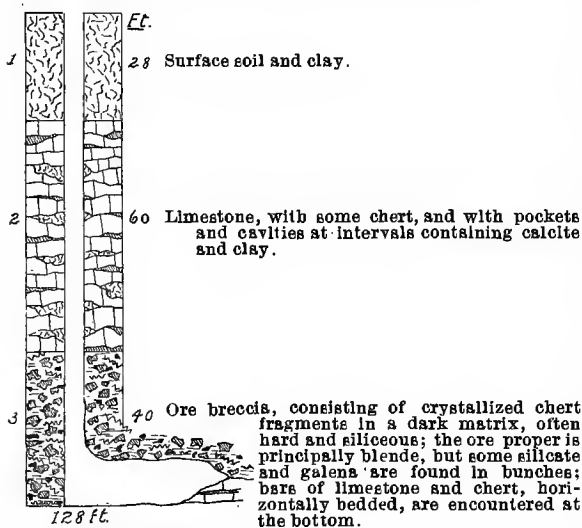


FIG. 175. Section of shaft of the Oriental mine.

Above the top of the drift, which is about 15 ft. high, no blende or galena were found in the breccia while sinking the shaft.

As illustrating the extreme variability of the ground here, we note the fact that 200 ft. north of this shaft another was put down to a depth of 150 ft. and no limestone beds were encountered; all was loose material or breccia.

A few shafts, in which greater or less quantities of ore were found, had been sunk east of the Oriental shaft. About half mile east is a belt of sandstone running in a north to south direction, which has heretofore been considered as unproductive ground, and as probably marking the limits of the ore deposits of this neighborhood. Drilling was

in progress here at the time of visit, and in one hole 80 ft. of this sandstone was passed through, and under it 50 ft. of broken limestone called 'limestone boulders.' Shafts had also been sunk near here in the sandstone. This rock is micaceous, and undoubtedly a Coal Measure formation, apparently occupying an oblong depression in the Lower Carboniferous rocks. Though doubtless barren of ore itself, there is no reason why the ore should not be found in the rocks underlying it.

THE PORTER SHAFT OF THE ST. LOUIS & AURORA MINING CO.

This company's land is about one mile east of the town and south of the railway. The shaft when visited was 75 ft. deep, in addition to 12 ft. more in the sump. The following section was observed here:

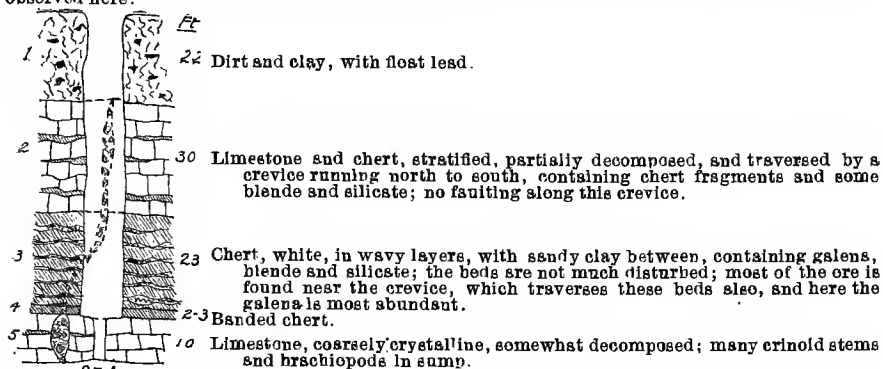


FIG. 176. Section of the Porter shaft. In an adjoining shaft encountered, next, 1 ft. of chert, and then 11 ft. more of limestone like the last.

The ore, found in No. 3 of this section, lay in a run which had a N.-S. course, and is between bars of barren rock on both sides; a shaft, 500 ft. east, however, did not strike any solid rock within a depth of 68 ft. The ore proper was principally "silicate," though a large amount of galena had been taken out, but this is mostly in the upper workings; some blende was also found. Calcite was very abundant in tallow clay, but no dolomite or pyrite were seen, though some of the latter was found in neighboring shafts. Calamine occurred deposited on calcite, and calcite on galena and blende.

A drill-hole, put down about 125 ft. east of this shaft to a depth of 217 ft., went through alternations of limestone and chert for the whole distance; in the upper 80 ft., lead and zinc minerals were quite abundant; below this, a little lead and a good deal of blende were encountered at 120 ft.; a further trace of lead was found at about 150 ft., but below this, no trace of these ores was seen.

THE LINE SHAFT.

This shaft was on the Kentucky company's land, about a quarter of a mile north of the last. The total depth was 120 ft. Drifts were driven at depths of 45, 60 and 85 ft. Galena was found principally in the upper drift, with calamine; in the second drift some blende was found, but most of the blende and calamine were taken from the lower drift, where some dolomite also occurred. Calcite was found in the upper drift. The ground was very much broken, and was seen to contain large and small fragments and blocks of limestone, while ribs and bars of this rock were frequently encountered in drifting. The ore body was entirely brecciated, and no remains of stratification were observable, as in the last described mine.

LOUISVILLE MINING COMPANY.

This company owned about 20 acres of the famous Orchard tract, which belonged to Rev. S. M. Elliot, one of the pioneers in this district, and covered the northern half of the NW. $\frac{1}{4}$ of the SW $\frac{1}{4}$ of section 7. The company was composed mainly of residents of Louisville, Kentucky, Mr. W. W. Johnston being the manager and superintendent. They were doing some mining on their property, but lease out the greater part to other parties.

These mines, as described by Mr. Robertson, are located in the same limestone as the others in this vicinity. A drill-hole put down here to a depth of 250 ft. showed alternate beds of limestone and chert for the whole depth. The ground in which the mines are situated is very wet and soft; much of the limestone has been removed by solution, and fractured chert, tallow and joint-clays occupy the spaces. The ground was what miners call "heavy," i. e., very liable to swell and crush the timbering, and it was almost impossible to keep a shaft in alignment unless braced with timber of unusual dimensions.

Abraham and Company's mine.—The mine belonging to these parties may be taken as a typical one for this tract. The shaft was about 60 ft. in depth, and penetrated a series of layers of lime-

stone and chert until the ore body was struck. This ore was about 30 ft. thick, containing but little limestone, and that generally as isolated fragments or blocks. The ore was mainly "silicate" with trifling amounts of blende and galena. It was accompanied by a gangue of crushed flint and tallow and joint-clays, that only partially filled the spaces formerly occupied by the limestone. The calamine occurred in very beautiful crystalline aggregates of stellate and mammillary forms, and in delicate incrustations on tallow clay.

The tallow clay itself carries considerable zinc, probably as silicate, but hardly enough to pay for extracting under present circumstances. It is light salmon or white in color, and of a very homogeneous structure or texture. Little or no grit is perceptible. It usually has the consistency of plaster of Paris that has set sufficiently to allow of its being cut with a knife. The joint-clays are, as a rule, darker in color, being of various shades of red, less homogeneous, and tougher and more plastic. The chert is usually bluish drab in color, quite brittle and generally much fractured. It rarely occurs in layers or strata of considerable thickness.

In the country immediately east and west of Aurora, considerable prospecting and some mining have been done. On the *Dayton land*, just west of town, large quantities of ore have been raised, as is shown in the table of Aurora productions. About a mile and a half east of the town is the *Selburn or Nevada Gem mine*, which has produced much ore. At the *Seamore mine*, about a mile and a quarter north of Aurora, a small coal-pocket was encountered.

THE MOUNT VERNON MINING COMPANY.

The mines of this company, also known as the *Statts City mines*, were controlled by citizens of Mount Vernon. They are located in the SE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 26, township 28 N., 28 W., about ten miles from Mount Vernon, the nearest railway point. Prospecting and work on a small scale had been conducted here since 1888, but not until 1893 were operations at all extensive. Two steam hoisting and concentrating plants had been erected and were operating at the time of examination. According to the State Mine Inspector's reports, the yields for the years ending June 30 were as follows:

	Lead ore		Zinc ore.	
	Tons.	Values	Tons.	Values.
1892 Statts City M. Co .....	.....	.....	70	\$1,575
1893	10	\$420	100	2,000

The information was given to the writer at the mines in December, 1893, that there had been shipped up to that date about 200 tons of dressed blende and 60 tons of galena.

The shafts were 120 ft. deep, and were in alternating beds of limestone and chert all the way down. These beds, over the ore body, are not disturbed and occupy horizontal positions, but they are traversed by small calcite veins in all positions and running in all directions; as the ore body is approached these veinlets are mostly north and south, and are nearly vertical. The bottom 20 ft.

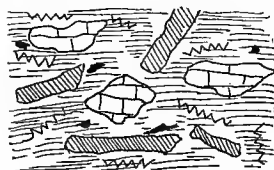


FIG. 177. Sketch of ore body in the Mt. Vernon Co.'s mine.

of the shaft penetrated an ore-bearing breccia in which drifts about 12 ft. square were driven. This breccia was composed of chert and limestone, the blocks of the latter, though broken, not being very much disturbed. The adjoining cut, from a sketch made in the mine, illustrates the structure here. In this breccia and around the fragments was a dark-gray, soft clay or mud, and much calcite in crystalline masses. In this, the blende was diffused; comparatively little galena was found. The drift at the bottom extended about 250 ft. a little W. of N. An upper drift, at a depth of about 80 ft., was driven 50 W.; this was not examined; the ore here was also principally blende, with some "silicate" and no galena.

At other points in the county about Mount Vernon, lead and zinc ores are found, and, at some of these, mining has been tentatively begun. Thus, on Mr. Shue's land, about three miles southeast of Mount Vernon, blende is reported to have been struck in some six or seven shafts, ranging up to 75 ft. in depth; the blende was found in nearly all between the depths of 25 and 40 ft., and in one shaft the ore was 2 ft. thick. Similarly, Mr. Norman Gibbs, of Mount Vernon, informs us that in the northwestern corner of the county, on the east line of the NW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 35, township 29 N., 28 W., at the bottom of a well, a vein of galena 2 to 8" thick was struck, running NE.-SW., in limestone. Other like occurrences are reported in different sections.

In the northeastern part of the county, mining was quite active in past years, in deposits belonging properly to the Ash Grove group, described later. Nothing has been done there during late years, and we, hence, are unable to add descriptions.

THE PURDY MINES.

A few miles east of Purdy, in Barry county, is a group of mines, generally known as the Purdy mines, from which a good many tons of ore have been shipped during recent years. In the table on p. 508, of chapter XIII, furnished by Mr. J. G. Marriott, of Purdy, is an exact statement of the productions to date of these mines.

Examinations of these deposits were made by Mr. Robertson in 1891, and he describes them as follows:

Drake or Henderson mines (R)—This company leases 9 acres of land in sections 34 and 35, township 25 N., 27 W. The mine is about $3\frac{1}{2}$ miles east of Purdy, on the St. Louis & San Francisco railway, the shipping point to which all ore was hauled.

The mine was opened in May, 1888, by Geo. H. Hofford. Shortly after this it passed into the hands of Dr. Wiley Brown, who held it until March, 1891, when it was transferred to Messrs. Seamon, Richards & Drake. Mr. E. A. Drake was manager.

The workings are in upper limestone beds of the Lower Carboniferous formation, here coarsely crystallized, hard and pure, as much as 75 feet thick, with some interbedded chert; beneath this, heavily bedded chert of the same formation crops out. In the vicinity, masses of chert were seen, with no stratification planes apparent, the chert being gnarled and knotted in a very peculiar manner. North and east of this mine such chert is particularly abundant.

The mine had been opened by a drift run into the side of the hill, which followed irregularly the course of the ore. The workings widened and narrowed considerably, as the nature of the roof and the amount of ore in sight demanded. A shaft was also sunk 100 yards to the east, on the top of a hill, and, from this opening, a little lead ore had been taken out. Recently, a drift has been run from the main drift to intersect this shaft.

The ore consisted mainly of calamine, although considerable blende was found. These generally cemented broken fragments of chert, but were also, at times, rudely interbedded with the limestone and chert; especially was this true with the blende. Large quantities of joint and tallow clays were found associated with the ore.

The ore body appeared to be in the form of a "run," of the nature of others previously described; it was approximately 50 feet or less in width, and had been opened for 20 to 30 ft. in depth and for a distance of not less than 75 feet in length. The mine had been very irregularly worked in the past, and it was almost impossible, in consequence, to define with any accuracy the shape of the ore body. The calamine and the zinc blende were the only minerals noted here at the time of inspection.

Kelley & Anderson mine (R).—These diggings, known also as the Dodge Hollow, are about $\frac{1}{2}$ mile south of the Henderson diggings, and are about the same distance from the railway. They were opened in 1888, by Samuel Dodge, and very little has been done on them since. Several parties have had control, Messrs. Kelley & Anderson being the last at the time of inspection. They are situated in the same position, geologically, as the Henderson mine, and the ore body is similar. The main product is calamine, although some blende is also found. There is also a little galena obtained here, and some amethystine and incrustations of pyromorphite and cerussite.

Owing to the entire stoppage of work at the time the mines were visited, the underground features could not be examined. The ore was reached by means of shafts, varying in depth from 25 to 50 feet. The country rock is the same limestone described at the Henderson mine, but contained more chert. It was not so thick, either, the heavily bedded chert beds being closer to the surface, in a much broken and disturbed condition. About 50 tons of "silicate" had been raised to date.

Stanberry diggings (R).—These diggings, operated by Messrs Rathburn & Shoat of Carthage, are in section 28, township 25 N., 26 W., about ten miles south of Aurora, where the ore was hauled. The ore is entirely galena. It occurred in pockets lying in a general east and west direction. A drift had been run into the hill 4 to 6 ft. high, and on either side pockets were found, containing galena in fragments varying from $\frac{1}{2}$ " to 12" in diameter. The drift ran for about 150 ft., and, at the end, there appeared to be a "mud opening" or cave, largely filled with liquid mud and broken fragments of rock, in which much galena was found. Little or no prospecting had been done on either side of the drift, so that the extent of the deposit was not known. Some two or three tons of lead ore had been taken out of this mine.

McDowell diggings.—These are in the SE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 33, township 26 N., 25 W. The mine was not worked in 1891, but was reopened in 1892. The deposit lies in Burlington limestone, and has produced some fine ore. Prospecting had been carried on with some success by David Doty in section 23, township 24 N., 26 W., and by Lane & Canterbury in section 26, township 25 N., 26 W.

At other outlying localities small quantities of ore have been found, and some prospecting has been done. Thus, in Stone county, Mr. Robertson noted small quantities of lead mined by Mr. Marsh, in section 7, township 26 N., 24 W. Perhaps 5 tons of ore have been taken out altogether.

Lead has been found in the surface soil by T. H. Knapp, in the NE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 22, township 25 N., 24 W., and by John Hines, in the SE. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 18. The Logan brothers, of Logan, Lawrence county, have done a little prospecting in the NW. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 18, township 21 N., 24 W.

John McCracken found some lead on Wilson creek, near Galena. The exact locality could not be ascertained.

THE GREENE AND WEBSTER COUNTY SUB-DISTRICT.

This sub-district includes all of Greene county, the three western ranges of Webster county, and also townships 27 N., 23 and 24 W. of Christian county, and so much of southern Polk county as is included on the district map.

The principal mining camps are in western Webster county, on Pierson creek, near Springfield, about Ash Grove and near Brookline. At a few other scattered localities are diggings of minor importance.

As is shown on the district map, the greater part of this area is immediately underlain by Lower Carboniferous rocks; and the lower portion of this series, or the Kinderhook stage, is exposed in the southeastern portion, and some of the ore deposits are in its beds. In the northeastern quarter of the sub-district, the magnesian limestones and sandstones of the Silurian are represented, and some of the mines are located within these rocks.

THE WEBSTER COUNTY MINES.

The mines of Webster county, as shown on the map, are located mostly in the Lower Carboniferous limestones and shales, and partly in the underlying magnesian limestones. These mines were examined by Prof. E. M. Shepard, of Springfield, while acting as local assistant of the Geological Survey, and the following descriptions are prepared by Mr. Robertson from notes furnished by Prof. Shepard.

Hazlewood diggings (R & S.)—These diggings lie in section 16, township 29N., 17W. They were first operated by Ex-Gov. J. W. McClurg in 1844, who worked here at intervals until the war.

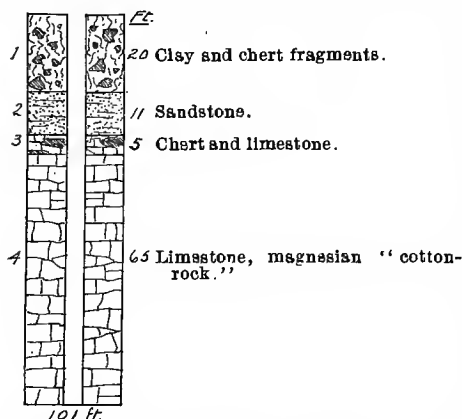


FIG. 178. Section at Teague Creek mines.

magnesian limestone. No ore was found in the sandstone, nor were there any crevices in it, save at one locality. In the Polly shaft, the section of figure 179 was measured.

In this shaft it will be noticed that, for the first 35 feet, the ground is composed of residuary material; then, for 10 feet, there is limestone considerably broken, and associated with much clay; beneath this lies a sandstone, somewhat ferruginous and not very hard, in which there is a distinct crevice 3 to 4 feet wide, trending N. 48° W., and dipping NE. This crevice was filled with

The lead was found in clay overlying magnesian limestone, and was obtained from shallow pits and shafts. Some 150 tons of galena were mined and smelted in a rude log furnace, and then hauled partly to St. Louis and partly to Linn Creek, Camden county. Since the war, the property has passed through a number of hands, and much money has been spent in prospecting for deeper runs of mineral, but so far with but scant success.

Teague Creek mines.—These mines were likewise prominent in the past. They are located in the SW. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 6, township 29N., 17W. There are here, as in other places, numerous shafts, at one of which, the Taylor shaft, the adjoining section was measured. The ore is found entirely in the clay, which is probably residuary from

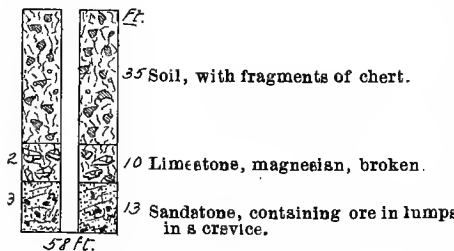


FIG. 173. Section at the Polly shaft.

Trusty Mines.—These also formed a prominent group in the past, but are now abandoned. They lie in lot 1, of section 5, township 29 N., 17 W. There were some 75 or a hundred shafts, the deepest of which was 35 feet. The galena lay almost entirely in the residuary clay, but crevices were seen in the limestone, running NE. and SW., which carried some ore attached to the side. The mines were opened in 1875, and had not been worked since 1882. About 25 tons of lead ore had been produced.

Marshfield Mining Company.—This company started work in 1891. A drill-hole 140 feet in depth had been sunk about three miles SE. of Marshfield, in section 24, township 30 N., 18 W., and some blende was obtained in the last drillings. A shaft was thereupon sunk, and the section illustrated by figure 74 of chapter X was passed through.

No. 8 of that section is extremely hard and siliceous. It contains small crevices, not continuous, that are filled with calcite, carrying more or less blende, of a very good quality. No drifting had been done when this mine was visited, and consequently only the face at the bottom of the shaft was seen.

In addition to these mines, Professor Shepard refers to some twenty-five other openings in Webster county, some of which are located on the district map. The most important of these are *Gates mine*, in section 3, township 28 N., 19 W.; the *Harper mines*, in section 33, township 29 N., 19 W., and the *Jackson mine*, in section 26 of the same township. The remainder are almost all prospect holes, and have yielded but little ore. Across the line, in Greene county, both north and south of Stafford, prospecting has also been done at points located on the map. Small quantities of ore were found, but no shipments are recorded from these localities.

THE PIERSON CREEK MINES.

These mines are located in the SW. $\frac{1}{4}$ of section 36, and in the NE. $\frac{1}{4}$ of section 35, township 29 N., 21 W., and also in the NE. $\frac{1}{4}$ of section 1, township 28 N., 21 W., in the valley of Pierson creek, a small tributary of the James fork of White river, not far above the mouth of the creek. They are situated, hence, about as low topographically as any point in the county. Geologically, the deposits are included in or below the lowermost beds of the Augusta stage, and it is probable that the Hannibal shales of the Kinderhook stage are represented here.

Mining was done at this locality as far back as 1844, for ex-Governor McClurg, who had lead ore mined and smelted from deposits at or near the Phelps mine. According to Prof. Shepard's notes, no further mining was done here until 1875, when work was resumed by gentlemen from Springfield and Joplin; but after some ineffectual attempts, work was again abandoned until 1885 or 1886. The land of the group of mines north of the Phelps mine is owned by Mrs. McFarland, and has been leased and sub-leased for a number of years back, the principal operations being those of the Pierson creek or Gumbo and Kodak mines, and those of J. A. Eaton, or the Ananias mine.

It has been impossible to obtain complete figures of productions of all these mines, but some few facts are added to illustrate the scale of operations during

clay, carrying blende and "aiticate." The ore occurred in irregularly shaped masses, and not in sheet form. This was one of the richest shafts on the property.

There had been more or less lead and zinc found in the vicinity of Panther creek, and also near the far-famed Devil's Den. In the latter locality, McClurg & Murphy erected a smelter in 1888, and reduced the lead obtained. The smelter was in operation for about one year.

past years. In 1893, three large concentrating plants were erected in close proximity, and the output for the past year is probably greater than that of any preceding one.

PRODUCTIONS PIERSON CREEK MINES.

		Lead ore.		Zinc ore.	
		Tons.	Values.	Tons.	Values.
Beginning to 1892 ^a	Phelps Mine.....	117?	.....	552?	.....
	Eversol & Eaton (Munford).....	.....	.....	18?	.....
	Piereson Creek (Gumbo and Kodak).....	215?	.....	2,000?	.....
1889 ^b	Phelps mine.....	23	\$1,012	172	\$8,956
	Piereson Creek M. Co.....	24	1,008	176	4,048
1890 ^b	Eversol & Eaton.....	.....	.....	38	968
	Phelps mine.....	12	525	50	1,250
	Piereson Creek mine (Sherman & Co.).....	16	768	163	4,075
1891 ^b	Eaton, J. A. & Co.....	12	625	200	4,500
	Gumbo M. Co. (Piereson Creek mines).....	80	3,920	555	12,494
	James River M. Co. (Phelps mine).....	.....	.....	20	460
1892 ^b	Ananias M. Co. (J. A. Eaton).....	40	1,920	200	2,800
	Gumbo M. Co.....	145	6,815	600	15,000
1893 ^c	Ananias mines.....	10	360	30	570
	Kodak mines.....	18	630	110	2,090
	Gumbo mines.....	62	2,250	410	7,790

^a Notes of E. M. Shepard

^b State Mine Inspector reports, years ending June 30.

^c From S. C. Johnston, from the company's books.

The Nathalie Mining Co.—The mine of this company is located about a half mile above the Phelps mine, on the western bank of the creek; it was formerly known as the Gumbo mine, and is immediately contiguous to the Kodak mine. Both of these were equipped during 1893 with new steam hoisting plants and concentrating works. The following description is the result of an examination made by the writer in April, 1893:

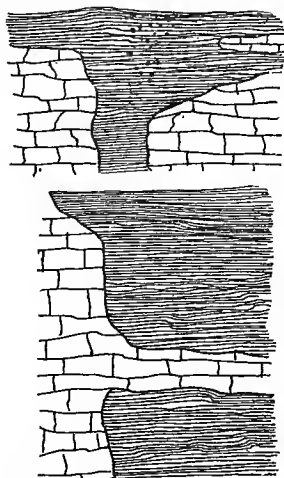


FIG. 180. Sketches of ore body at the Nathalie Co.'s mine.

The shaft was then only 34 ft. deep, and the ore was encountered at 14 ft. below the surface; the workings were in a bed of soft, drab shale, gritty and highly calcareous, called "gumbo;" it seemed to lie in a horizontal position, but the bed varied in thickness from 1 to 12 ft. or more; a hard, dense limestone occurred as a cap rock here, though, sometimes, massive blue shale immediately overlay the gray "gumbo." The ore was most abundant near the top of the latter, and consisted of crystals of galena and blende, both large and small; it was, however, also disseminated throughout the body of the shale in fine crystals, and occurred in larger crystals along crevices which traversed the roof rock; but it was never disseminated through this roof rock. These crevices, as exposed in this mine, are many of them mere joints, opened by solution, and run in all directions. No one prominent fissure or fault plane could be found here, though carefully looked for. The ore was also sometimes concentrated in the shale along the bottom rock, but is said to never penetrate the latter. Bosses, called "boulders," and ridges or bars of limestone were often found running through the mass of the shale in a very peculiar manner, as illustrated in the figures, very much as if the latter had been laid down

upon an eroded surface; the absence of any appearance of oxidation or other weathering effects is, however, opposed to this interpretation. Another, and a perhaps more probable explanation, is that these limestone ridges and bosses are merely more highly calcareous portions of the formation; possibly developed through some secondary introduction of waters containing lime in solution.

In the hill-side and bluff, just east of the creek, beds of Lower Carboniferous limestone and chert are well exposed up to a height of 100 or 150 ft. above the creek; they are undisturbed, and lie in a horizontal position. Several shallow shafts and pits had been sunk on this hill-slope, up nearly to the very top of the hill, along the line of a crevice running northwest to southeast. This crevice was well exposed in one of these shafts on the hill, and the rocks are not faulted along it; it is filled with breccia of country rock, through which a small amount of galena is diffused. The workings of the mines just described were, in a general sense, in the continuation of this crevice, but, as already stated, no such vein-like opening was detected in the mines themselves. Some are inclined to attach great importance to the crevices, and describe them as accompanied by great shearing and faulting of the strata. We are unable to detect such here, and do not see that these crevices are in any respect different from joint crevices found throughout the state and elsewhere, especially in limestone rocks, often unaccompanied by any ore whatsoever. In the present case, they doubtless have some relation to the distribution of the ore, but to consider them as so-called "true fissure veins," extending to indefinite depths, is extravagant, to say the least. At several localities in this vicinity evidence of faulting was seen, but no great amount of displacement can be demonstrated.

The Phelps and Eversol or Eaton Mines.—These mines are situated about half a mile southeast of those last described, and are both considered by Prof. Shepard as on the same crevices. They were not open for examination at the time of the writer's visit, and, hence, we can only include the following brief description extracted from Prof. Shepard's notes:

At the Phelps mine are two shafts located on crevices 75 ft. apart; these crevices have a course N 25° to 30° W., and extend northward through the Eversol mines. The shaft of the Phelps mine was sunk through 16 ft. of soil and clay, underlain by 43 ft. of shale, magnesian limestone and chert, with about 2 ft. of sandstone near the middle; below this, at the bottom of the shaft, were 3 ft. of sandstone and 2 ft. of shale. Ore was found at two levels here, the one near the top, in the shale, being most productive. The Eversol shaft was sunk 40 ft. through calcareous shale, the lower 9 ft. consisting of the blue "gumbo," containing blende and galena disseminated through it. Under this, 8 ft. of sandstone and chert were dug through. Very little calcite or other accessory minerals are found in these mines.

THE ASH GROVE CAMP.

Another important group of mines is near Ash Grove. As may be inferred from what has already been stated, these were worked as much as 20 years ago, and figures of production previously given show that several thousand tons of ore have been produced. Most of this mining has been immediately south of the town of Ash Grove, within a distance of a few miles, over the upland country or divide between Middle fork of Sac river and a small tributary to the east. The excavations are in Lower Carboniferous rocks, extending probably from the Lower Burlington through the Kinderhook beds; and in one shaft 250 ft. deep, a few feet of probably Silurian magnesian limestone were encountered.

The principal mines of this camp during recent years have been those of the McCord land, those of Dunlap & Co., Goetz & Co. and of Murray & North. The productions of these mines during the past four years are given in the following table:

PRODUCTIONS OF ASH GROVE MINES.

		Lead ore.		Zinc ore.	
		Tons.	Values.	Tons	Values.
1889 a	Ash Grove camp	23	\$876	280	\$4,264
1890 a	Duncan land	25	981	31	356
	Goetz land	10	440	20	240
	McCord land	175	7,700	250	3,250
	Murray, H., land	102	4,532	.....	.....
1891 a	Duncan, J. K. P.	3	145	60	720
	Dunlap & Co.	56	2,678	39	468
	Goetz & Co.	23	1,104	.....	.....
	Murray & North	20	955	100	1,095
	Pennsylvania M. Co.	6	288	.....	.....
1892..	Bay State M. Co.	3	128	.....	.....
	Goetz M. Co.	36	1,670	.....	.....
	Hurt (small diggings)	26	792	.....	.....
	Murray & North	155	7,120	40	520

a From State Mine Inspector reports, years ending June 30.

A number of these openings were visited by the writer in November, 1889. The following descriptions are from notes taken at that time:

The Murray mine of the Hutchins land.—This mine was located near the center of the SE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 32, township 30 N., 24 W. The shaft was about 70 ft. deep, and the adjoining

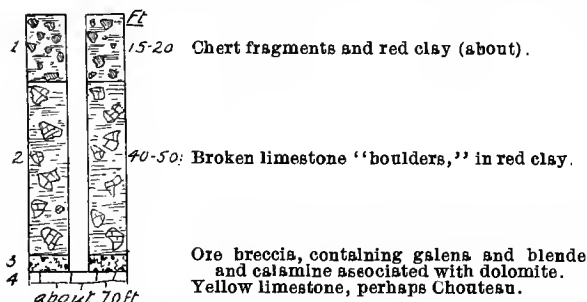


FIG. 181. Section at the Murray mine.

section illustrates, in a general way, the materials passed through in sinking this and other shafts of the neighborhood.

About a quarter of a mile south of this shaft was an old abandoned opening, around which were exhibited numerous blocks of ferruginous Coal Measure sandstone; limonite was also seen here, and frequently cemented chert fragments, forming a ferruginous breccia.

J. K. P. Duncan's land.—The openings here were situated in the SW. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 32, township 30 N., 24 W. The shaft was 95 ft. deep, had gone 20 inches into a yellow, Chouteau-like limestone at the foot, and had entered a blue limestone beneath it. The blende and galena were associated with a dark secondary chert, evidently the matrix of an ore breccia.

Dorrel land.—The diggings on this land were in the NW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 6, township 29 N., 24 W. Coal Measure sandstone blocks were abundant here.

On the Getty land, in the NW. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 33, township 30 N., 24 W., a number of shafts had been sunk to depths of from 20 to 30 ft., penetrating the yellow limestone 6 or 8 ft.; both galena and calamine were taken out here.

The Pennsylvania Company's Shaft.—During 1891 a shaft was started by a company of this name a short distance southeast of Ash Grove, east of the Gulf railway track, not far from the middle of section 23. This shaft was continued during 1892 and 1893 to a depth of 250 ft. It was visited by

the writer in July, 1893. The actual section could not be studied at the time, but, from information furnished by Mr. Hunt, superintendent, accompanied by an inspection of the dump-pile, the following record was prepared, and is believed to be substantially correct:

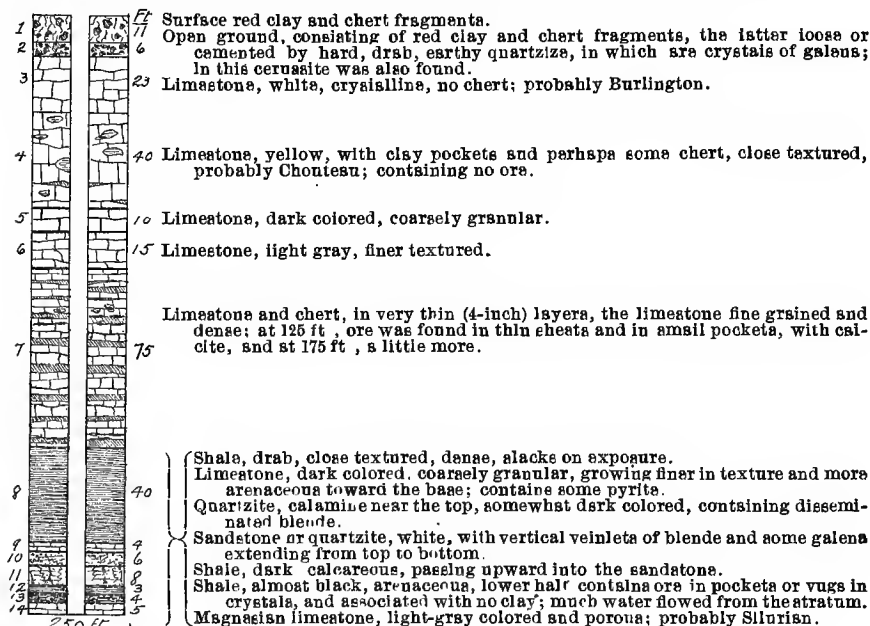


FIG. 182. Section of the Pennsylvania Co.'s shaft.

Most of the mining in this camp has been done from such deposits as are included in No. 2 of the above section, though, at times, they extend to greater depths and are geologically lower. The results reached in this shaft, considered together with the above fact, are adverse to the existence of ore at depths here.

In the year 1878, Prof. C. P. Williams, then acting State Geologist, made an examination of mines about Ash Grove. The notes of this examination, written out in connected form evidently preparatory to publication, were inherited by the present survey, and, as they have never been published, the mine descriptions are included here.

ASH GROVE MINES.

By C. P. Williams.

At Ash Grove lead mining operations have been prosecuted for some time back, in Keokuk limestone which forms the surface rock in this vicinity, at the level of upward of 1200 ft. above the sea. The mining work has been done chiefly in all four quarters of the SE. $\frac{1}{4}$ of section 28, township 30 N., 24 W., and in the NE $\frac{1}{4}$ of section 29, same township.

On section 29 a number of shafts have been sunk, the deepest of which was carried down to the depth of 50 ft. The lead ore was struck at from 15 to 30 ft. from the surface. Superficially, the ore was mainly carbonate of lead of the variety known as the "ash mineral," but in depth the galenite predominated. The ore was intermixed with clay, flint, limestone and "quartzite," and occupied irregular cavities in the limestone. In carrying down the deepest shaft about 10 tons of mineral were taken out. At another shaft, 183 ft. southwest from the first mentioned, the product was 25 tons. S. 65° W. from the last named, a distance of 115 ft., a third shaft, carried to the depth of 45 ft., struck galena, or blue mineral, at a depth of 30 ft. Three hundred feet from this shaft, on a

course S. 82° W., a shaft 19 ft deep showed much "cog" and "dice" mineral, intermixed with flint and oolite, the latter chiefly of the variety known as dog-tooth spar. In drifting 10 ft. from this shaft, with an opening 3 ft. high, by about 4 ft. wide, between 5000 and 6000 pounds of galena were removed. A section of this shaft exhibited the following:

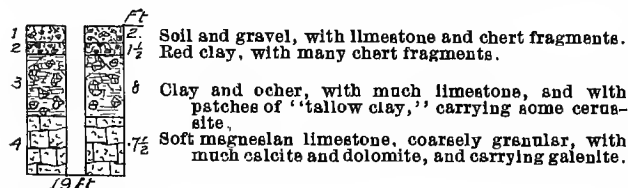


FIG. 183. Section at Ash Grove.

The rock beneath this last is a close grained, compact, and somewhat siliceous magnesian limestone, of a blue color, containing 41 per cent of magnesium carbonate, and is generally regarded as the bed-rock or inferior limits of the lead-bearing zone."

PICKEREL DIGGINGS.

By C. P. Williams.

"Ten miles nearly due southward from Ash Grove, the lead-bearing members of the Keokuk series constitute the surface rock, and were worked for lead ores. The diggings are chiefly in the northern part of section 33, township 29 N., 24 W., in the vicinity of Pickerel creek. The ore occur at the same horizon as at Ash Grove, and the conditions of the latter are very closely reproduced at Pickerel.

The diggings are near the summit of a hill, which attains an elevation of about 45 ft. above the ravine at its base, or 190 ft. above the Pickerel at the crossing of the new road from Springfield to the Chalybeate springs of Lawrence county. The mineral is struck at depths ranging from 1 to 26 ft. It occurs mixed with chert and limestone pebbles, in a dark red or yellowish clay, non-plastic and ochreous, with patches of a non-plastic or 'tallow' clay. Limonite iron ore is found in patches and seams. Much of the ore thus far found has been "dry-bone" "ash mineral."

From three prospects nearly 12½ tons of mineral were taken. The ore is hauled to Ash Grove, a distance of 10 miles as stated, and is treated at the furnaces at that place.

The 'bed-rock' resembles closely that reached at Ash Grove, and does not differ from it very widely in composition.

The mine was opened in 1875, and perhaps 200 or more pits have been sunk, nearly all less than 15 ft. deep. Some 4000 tons of ore are reported to have been hauled from here to Ash Grove."

In addition to these mines immediately about Ash Grove, a number of localities are indicated on the district map, where, according to Prof. Shepard's notes, ore has been found and some prospecting has been done, resulting, in instances, in the production of a few hundred pounds of ore, principally galena. These diggings are mostly a few miles east of Ash Grove and north of Bois D'Arc on Clear creek; also, farther north, about Graydon springs, a few pits have been dug, from which float lead has been obtained.

In the northeastern corner of the county, near Fair Grove, is what is known as the Bull Winkle or Baas mine. This, as described by Prof. Shepard, is in the southwestern corner of NW. ¼ of the SE. ¼ of section 35, township 31 N., 21 W. Ore was discovered here about 1873. Work was begun in 1890, and some ore was found in the surface clay. At a depth of 8 ft. a crevice in magnesian limestone was encountered, with a course N. 40° W., and varying in width from a few inches to 18 inches. The ore was found in flattened sheets along the walls of the crevice, and also disseminated through the gangue, with but little calcite. The shafts were about 30 ft. deep. About 1200 pounds of lead ore were taken from this mine.

THE BROOKLINE CAMP.

Mining about the town of Brookline, 10 miles southwest of Springfield, was begun about 20 years ago, on what is known as the Potter tract of land. Mines were operated here for a few years, and, in 1876, a furnace was built for smelting the ore. Up to the present time, however, from the best information we can gather, not much over 200 tons of lead ore, and possibly an equal amount of zinc ore, have been produced. The workings were abandoned for a number of years after 1878, but mining was resumed there in 1891, at the Nixon mine. For the year ending June 30, 1892, the State Mine Inspector reports the production as three-quarters of a ton of lead ore and 59 tons of "silicate" of zinc. This ore was excavated very near the surface, the shafts being not over 15 ft. deep.

The principal older diggings about Brookline were the Potter, Armstrong and Deputy mines. The following descriptions are taken from the notes gathered by Prof. Shepard, largely from Mr. W. M. Armstrong, of Springfield, to whom he expresses indebtedness.

The Porter shaft (S.).—This land is in the SE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 2, township 28N., 25W. The ore was discovered about 1873, and mined at depths from 25 to 50 ft. in subsequent years, and one shaft was sunk to a depth of 95 ft. During 1875 and 1876, Mr. Wilson operated this mine and took out, it is estimated, over 150 tons of ore. The ground was very soft and wet, and frequent caving of the works caused it to be abandoned. The ore was almost wholly galena, though some "silicate" was found, and, at the bottom of the shaft, a run of ore, 3 ft. thick, carrying blende, is reported. Much calcite, dolomite and clay were associated with the galena.

The Armstrong diggings (S.).—These are situated in the E. $\frac{1}{2}$ of section 11, same township. Very large sink-holes, with cave openings at the bottom, are found in the northern part of this eighty, in one of which a considerable deposit of ore was found. West of this, galena was found at the surface in 1875, and a number of shafts were sunk, from which 2 to 3 tons of "silicate" were taken out. About a quarter of a mile south of this are what are known as the Old Silicate diggings. Everything was fallen shut here at the time of examination, and no study of the ore could be made.

About ten miles southwest of Brookline, and a few miles south of Republic, a few diggings are located on the district map. These are little more than prospects, and developed only a small amount of ore. Two of them were open in 1890, and are now abandoned.

THE CHRISTIAN COUNTY SUB-DISTRICT.

Within this sub-district are included all of Christian county, with the exception of the two northwestern townships, and also townships 25 and 26 N., ranges 22 and 23 W., of Stone county.

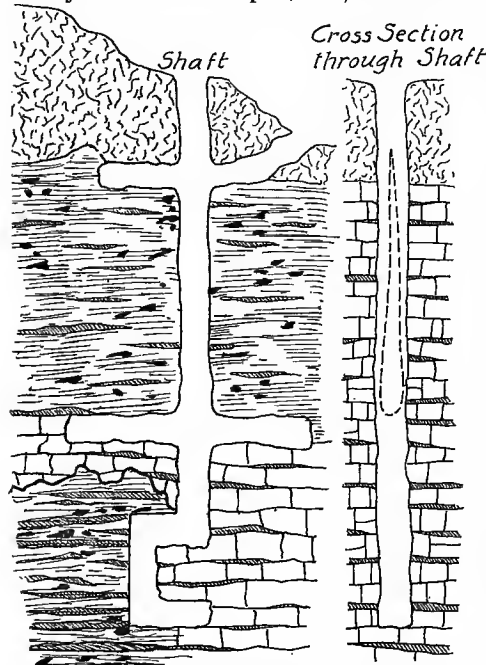
The principal camps are: the Elk Valley mines, including the Alma mines south of Ozark; the Finley Creek mines northeast of Ozark; the Burkhart or Swan Creek mines east of Sparta, and the Turkey Creek mines southeast of Chadwick. In addition to these, there are a number of outlying diggings of minor importance, located on the map. The majority, and the most productive of these mines are in the Lower Carboniferous rocks, principally in what appears to be the Burlington limestone. A few outlying deposits in the southern and southeastern portions of the sub-district are, however, in the Lower Silurian magnesian limestones.

Few figures of production, even during recent years, can be given over and above what are included in the tables on p. 509. Such additional data as we have been able to collect, are in the following descriptions.

THE ELK VALLEY OR ALMA MINES.

This group of mines is the most important in the county, having produced, perhaps, half of the total yield; work has been done here nearly 40 years. They are located about three miles south of Ozark.

The rocks containing the deposits here are the lower strata of the Burlington, and consist of the characteristic crystalline, gray limestone, associated with some chert in thin beds; calcite is also abundant in the limestone. This locality was visited by the writer in April, 1893, and the following notes were gathered:



The Ozark Mining Company's shaft—This shaft is situated, approximately, near the middle of section 35, township 27 N., 21 W. It was sunk on a vertical crevice in the limestone running S. 15° E. An opening on this crevice was first struck at a depth of 25 ft., and continued down to a depth of 95 ft. It was quite narrow at the top, and the greatest width was at 80 or 90 ft., where the walls were about 7 ft. apart. These walls then came rapidly together, and the shaft was sunk 20 ft. deeper in solid rock, which contained no perceptible crevice. An opening was then struck on the north side of the shaft, and an offset was made, and sinking continued in this; this last opening proved to be a cave, the width of which was shown at the time to be at least 20 ft., and an undetermined amount more. In this lowermost opening, layers of white chert were said to alternate with soft red clay, each being 6 to 8 inches thick; in this clay were galena and silicate. The distribution of the ore was irregular, much of the clay containing none. The adjoining cross section and longitudinal section give an idea of the character of the deposit.

FIG. 184. Sections of the Ozark Mining company's shaft.

Large amounts of surface lead were mined here in past years. About three fourths of the product has been galena, and the remainder "silicate" and some blende. The silicate was principally in the deeper workings; but very few shafts yielded any considerable quantity. All the crevices of this tract are in parallel directions to the course above given.

About two miles down the valley to the west are what are known as the *Keltner diggings*, which were all shallow, the ore being found near the surface; other diggings also extend up the valley to the east about one mile.

Other mines of this camp were visited by Prof. Shepard, and the following descriptions are taken from his notes, all excepting the first having been obtained from him by Mr. Robertson.

The Elk Valley diggings (S.)—These were owned by L. C. Lee & Co., of Springfield, and are located in the S. $\frac{1}{2}$ of the NE. $\frac{1}{4}$, and in the N. $\frac{1}{2}$ of the SE. $\frac{1}{4}$ of section 23, township 27 N., 21 W. There are here a large number of parallel crevices, from 40 to 200 ft. apart, crossing a small ridge. On these crevices numerous shafts have been sunk from the valley of Elk creek over the ridge, having a magnetic course N. 25 to 28° W. The rocks are Lower Carboniferous limestone. The shafts vary in depths from 60 to 100 ft. As a rule, galena was found in the upper runs, "silicates" in the middle and blende in the deepest. Several rich deposits were found in flat openings, or horizontal cracks between the bedding-planes of the limestone. A very moderate estimate of the production of this mine is 40 tons of lead ore and 50 tons of zinc ore.

Lang mine (S. & R.).—This mine is situated in section 7, township 26 N., 20 W. It was discovered by John McGuire in 1879. The ore was largely silicate, and occurred in a crevice in the Burlington limestone. The crevice was about 3' in width and had a course of N. 20° W.; the rock dipped strongly to the west. About 200 tons of "silicate" had been shipped from this mine.

Miller diggings (S. & R.).—These diggings are in the SE. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 1, township 26 N., 21 W. This is part of the old Alma tract. It was discovered in 1878 and worked for about two years, and was reopened in 1887 by W. H. H. Miller, who leased it to Ryland & Co. of Aurora. There are a number of shafts here that were worked by individual miners. The surface clay and chert are about 20 ft. thick, and, under this, some 30 ft. of limestone is shafted through. A crevice was opened here from 2 to 7 ft. wide and running N. 20 W. The ore was entirely galena, and was found in clay with blocks of limestone and chert. One or two tons of galena had been mined up to 1892.

THE FINLEY CREEK MINES.

This group includes a number of small diggings, which have been worked at intervals during the past thirty years. The following descriptions of different mines were written by Mr. Robertson, from notes furnished by Prof. Shepard:

McClellan diggings (S. & R.).—These are in section 8, township 27 N., 19 W. They were discovered in 1860, by Thomas Compton, who worked for a short time only. They were reopened in 1888, by Thomas McClellan. The shaft was sunk mainly in magnesian limestone, in which a crevice was encountered running N. 7° E. Hannibal sandstones and shales crop out near the mouth of the shaft. Some blende and "silicate" were obtained, the latter lining the crevices and cementing fragments of limestone.

Harper's mine (S. & R.).—This is in the SE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 33, township 28 N., 19 W. The mine was discovered and worked in 1873, when lead ore was mined and hauled to Marshfield. The shafts are in magnesian limestone, overlying sandstone cropping in the hills near by. The ore is found in crevices in the limestone, running N. 35° E.

In addition to these openings, Prof. Shepard tabulates in the same township, and we have located them on the district map: the Talman mines, in sections 6 and 7 and 12, the Plummer shaft in section 10, and the Finley Creek Mining company's in section 15.

THE SWAN CREEK MINES.

The mines which are included in this group are the oldest in the county, and the aggregate output to date has been large. The old Price, Bray & Co. mines, referred to by Swallow in 1858, are here. He described them as in the SE. $\frac{1}{4}$ of sec-

tion 9, township 26 N., 19 W.; some thirty shafts had been sunk, in which lead was found in clay and crevices in limestone. The following descriptions are either directly from Prof. Shepard's notes, or are from notes taken from his by Mr. Robertson:

Burkhardt's diggings (S. & R.).—These diggings are situated in the NW. $\frac{1}{4}$ of section 12, township 26 N., 19 W. There are about a hundred old shafts here, mainly in the clay overlying sandstone. The deposits are probably residuary ones from the magnesian limestone. About 150 tons of galena have been produced here. No work is now being carried on.

The Hornbeak diggings (S.).—These mines are a portion of a large group including the Purdom mines, which were worked here many years ago. They are situated in the SE. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 36, township 27 N., 19 W. They were discovered about 1854, and, according to Mr. Hornbeak, have yielded some 50 tons of lead ore, but very little zinc. In the main shaft, the following section was obtained:

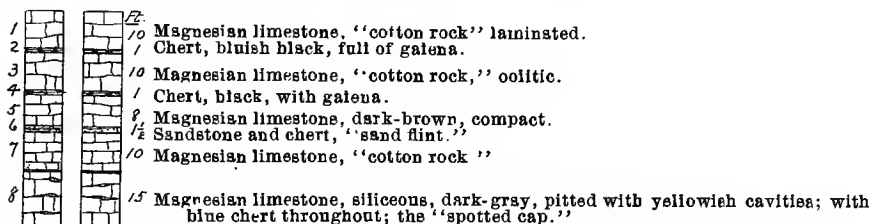


FIG. 185. Section at the Hornbeak diggings.

Under this, some 25 ft. more of magnesian limestone has been dug through in other shafts.

The ore is mainly galena, though a little "silicate" was found. The beds numbered 2 and 4 were very rich in ore. The galena had penetrated the chert beds on each side of a crevice running N. 16° W., in flat, irregular, crystalline sheets, from $\frac{1}{4}$ inch to over 1 inch thick, cementing the thin layers of chert. In No. 8, the "spotted cap" valuable runs of ore were found in cracks and crevices. At the base of this limestone, rich deposits are found in "clay openings." Very little gangue is associated with the ore, and only a little calcite.

O'Haver diggings (S. & R.).—They are located in the SE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 35, township 27 N., 19 W. These diggings were discovered and worked in 1855-56. They consist of a large number of shallow shafts in the valley along Lost creek. They have yielded about 50 tons of lead ore. The country rocks are magnesian limestones and cherts, overlying sandstone. The ores occur in crevices in the limestone. One crevice runs N. 26° W., and "laterals" run N. 65° W.

The Dysart diggings (S. & R.).—These are situated in section 1, township 26 N., 19 W. The country rocks and the modes of occurrence of the ores are similar to those at the Hornbeak mines.

McFadden diggings (S. & R.).—These mines, also known as the Patton and Old Field diggings, were discovered about the same time as the Harver. Some 200 tons of lead ore have been obtained. They are situated in the NW. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 1, township 26 N., 19 W. The conditions of occurrence of the ore are like those of other mines of this camp just described.

Boaz mines—These diggings are in the SW. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 9, township 26 N., 19 W. They were discovered about 1853, by E. Melton and J. C. K. McFadden, who also first worked them. They furnished a large quantity of lead to the Confederate forces, who mined and smelted it secretly for several years. The lead is found in the thick clay overlying the magnesian limestone, which latter is here about 60 ft. thick. Zinc ore, in the form of "silicate," has been found in the deeper shafts. Sandstone occurs in the valley. It is estimated that about 500 tons of lead ore have been taken out of this mine.

Rassieur mines—The diggings of this mine, recently worked by Col. J. E. Phelps, are in the N. $\frac{1}{2}$ of the NW. $\frac{1}{4}$ and in the W. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 7, township 26 N., 19 W. They were discovered about 1850, and to date, the estimated output is 50 tons lead ore. One shaft, recently sunk, was 30 ft. deep, and ore was taken from a fissure 6 ft. wide, in compact magnesian limestone.

THE TURKEY CREEK MINES.

In this group are included a number of diggings located on Turkey creek, a small tributary of Swan creek, in section 24 of township 25 N., 19 W., and in sections 8, 9, 17, 18 and 19 of township 25 N., 18 W.

The Adams diggings.—These are the easternmost of this group. They were visited by the writer in April, 1893, and, from his observations and notes furnished him by Mr. Isaac Adama, it appears that a shaft 68 ft. deep and other shallow pits had been dug along a crevice in magnesian limestone. This crevice was about 6 ft. wide at the top, and closed and reopened at intervals to the bottom of the shaft. It was filled with red clay, carrying galena. Ledges of chert extended across the opening into the rock, showing that no faulting had taken place. Galena was found in the upper 45 ft., but, below this, blende appeared and continued almost exclusively to the bottom of the shaft. Almost no carbonate or silicate of zinc were found. Some calcite and some pyrite were associated with the ore. Mr. Adama estimated that about 150 tons of galena had been hauled away from here during the last five years. At the upper mine, about half a mile up the creek to the east, two crevices were worked running northwest, and several parallel to these were found. They are a little wider than those of the lower mines, but are otherwise similar.

Prof. Shepard examined these deposits in 1890, and, in a private report to the company upon the deposits of sections 21 and 19, states that he located three or four fissures running N. 20 to 30° W. Along one of these he detected a fault with a throw of one foot. At another group of mines, three-quarters of a mile east, a strong fissure was observed striking N. 35° W., and parallel to this were others; cross-fissures intersecting these were also recognized.

The Roberts diggings.—These are located in sections 8, 9, 17 and 18 of township 25 N., 18 W. They were discovered about 1879, and have been worked at intervals since. In 1891, they were opened by Messrs. Hornbeak & Lee, of Sparta, who took out a good deal of ore. The shafts are in magnesian limestone and are about 20 ft. deep. Up to 1891, it was estimated that about 25 tons of galena had been taken out.

The Barber Creek diggings.—These are located near the northwestern corner of section 16, township 25 N., 19 W., on the edge of Barber creek valley. Near the level of the creek, a massive bed of magnesian limestone was exposed, containing some chert. The ore, mostly galena, is said to occur in pockets in this limestone, 6 to 18 inches in diameter; but very little ore had been taken out. A shaft near the level of the creek was dug about 40 ft. deep, and one farther up the hill was 102 ft. deep, and from the bottom of this a drift was driven 25 ft. southwest. At the creek level, a tunnel was run into the hill about 35 ft. Quite a substantial plant was built here, and this, together with the developments, had consumed some \$15,000, without there ever having been a car-load of ore produced. The plant was idle at the time of inspection, and remains so to the present day, a monument of the folly of expending large sums in equipments before even the presence of an ore body is demonstrated.

THE ARMSTRONG DIGGINGS.

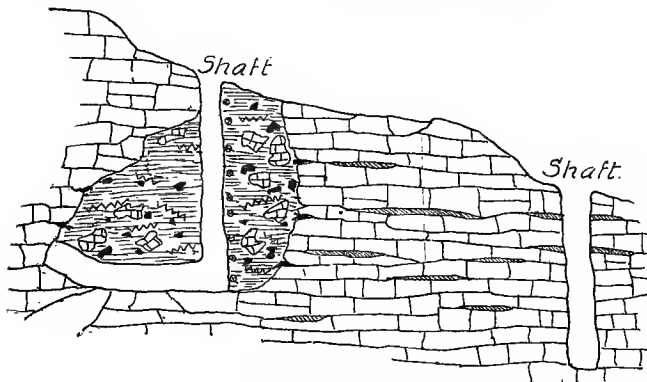


FIG. 186. Sketch at the Armstrong diggings.

Under this heading we include a few diggings and occurrences of ore about ten miles south of Ozark, in section 6, township 25 N., 20 W., on Bull creek. The locality was visited in April, 1893, by the writer. At that time, two shafts were being operated in a small ravine about half a mile north of the creek. A milling plant was also erected here, and, as in the case of the

Barber Creek mines, much money had been spent on the strength of mere future possibilities. The depths and relative positions of the shafts are shown in the preceding sketch. The upper shaft was sunk on a crevice with a lenticular opening, which ran N. 50° E. (mag.) in solid magnesian limestone. This crevice was filled with clay, decomposed limestone, calcite, galena, blende and some pyrite; no barite was observed. The crevice is a simple opening through solution, and no faulting had occurred along it. Some white chert, in lenticular layers, is found in the country rock. The galena sometimes penetrated the wall-rock, along joints and planes of fracture, but was not disseminated through it. Drusy cavities were abundant in the limestone, coated with small quartz crystals, and drusy quartz is found in loose masses abundantly over the hill-sides.

About half a mile up Bull creek from this point, on the northern hill-side, an outcrop of "silicate" was visited, which is worthy of further attention. Small veins and streaks of galena running through the country rock are reported at a number of localities in this vicinity.

THE WRIGHT COUNTY SUB-DISTRICT.

This sub-district embraces a small tract of country immediately about Mansfield, in townships 28 and 29 N., ranges 15 and 16 W., to the limits of Wright county and of the district map. Lead mining has been prosecuted in Wright county for nearly forty years. The early diggings were in the northern and eastern portions of township 29 N., 16 W. In the SW. $\frac{1}{4}$ of section 11 of this township, B. F. Shumard, in 1856, described the Prock diggings, whence about 150 pounds of lead ore had been taken. The galena appeared in well-formed cubes and cavities, in sandy, magnesian limestone, accompanied by calcite; it was never found in veins, but always in bunches in the rock.

The first period of active mining in the county seems, however, to have been about 1876, when a number of deposits of lead and zinc ore in the vicinity of Mansfield were operated for a few years. Since that time, work was spasmodically conducted up to the last two or three years, when a revival of mining has taken place, and quite large quantities of ore have been produced.

The distribution of mines about Mansfield is shown upon the small map on this page. The deposits are in the upper members of the Lower Silurian limestone series, and consist of beds of massive and dense magnesian limestone, of cotton rock, and of a very arenaceous limestone which is almost a sandstone, all normally in horizontal positions. Over some of the higher portions of the surrounding country Lower Carboniferous beds have been identified. Detailed figures of production for the

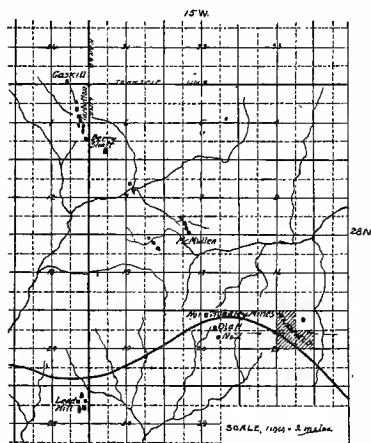


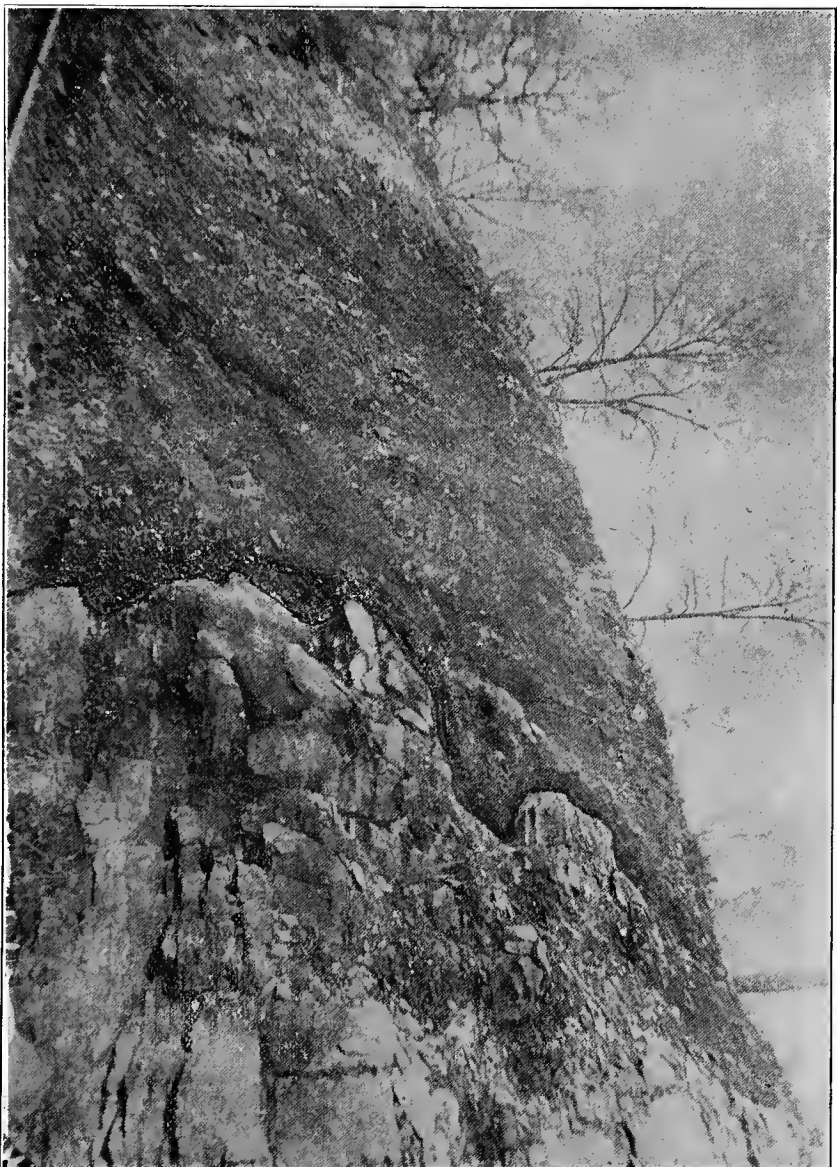
FIG. 187. Map of Mansfield and vicinity. through the assistance of Mr. J. G. Root, we are able to add the following table :

PRODUCTIONS OF WRIGHT COUNTY MINES.

	When opened	Years operated.	Lead ore.	Zinc ore.
			<i>Tons.</i>	<i>Tons.</i>
Berry mines	1876.....	1876-77-85-86-93.....	.....	620
Davis mines (Lead Hill)	1876.....	1876-77-78.....	325	.....
McMullin mines.....	1876.....	1876-77.....	5	225
Headley mines.....	1876.....	1877-79-86-93.....	.....	425
Totals.....	.....	.....	330	1,270

We will now give a brief description of the different deposits, derived from personal examinations and from observations made by Mr. Robertson and others :

The Lead Hill or Davis mines.—These mines were examined in 1891 by Mr. Robertson. The tract included in the mining property covers a large part of section 25, township 28 N., 16 W., and also portions of section 30 and of the adjoining township to the east. The mines are within a mile



FAULT IN RAILWAY CUT AT MANSFIELD.

or less of the Fort Scott & Memphis railway and Cedar Gap station. They were first worked about 1876, by John Davis, who hauled the ore in wagons to Marshfield, on the St. Louis & San Francisco railway, then the nearest railroad point, when it was shipped to St. Louis. The ore is entirely galena, occurring in clay and in crevices in the rock, which have an approximately E-W. direction. The gangue is a dark gray, arenaceous limestone with geode cavities lined with quartz, but otherwise quite compact.

About 80 feet below the level of the railroad, a tunnel has been driven into the hill. This tunnel is about in the center of the E. $\frac{1}{2}$ of the NE. $\frac{1}{4}$ of section 25, and extends for about 100 feet in a northwesterly direction. Some 15 or 20 shafts have been sunk at various points on the property, with more or less success, but, at the time of inspection, mining had been almost wholly suspended, a few men only working on royalties. It was estimated that over 300 tons of lead had been mined.

The Berry or Roote mine—This shaft is situated in the NE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 1, township 28 N., 16 W. It was visited by the writer in December, 1893. The mine was first opened in 1876, and was worked for a short time; it was reopened in 1895 or 1896, after which it was abandoned until quite recently, when the property was purchased by Mr. Roote. The shaft, which was 185 ft. deep, was filled with water at the time of inspection. According to Mr. Roote, a solid vein of 'silicate' and blende was struck at about 16 ft. from the surface; the course of this vein was N. 20° W. (mag.), the dip about 80° W. The foot-wall is said to be an arenaceous limestone, while the hanging wall is a drab magnesian limestone, this difference demonstrating a faulting along the crevice. At the top, the vein was 2 ft. thick, and increased to 3 $\frac{1}{2}$ ft. at the bottom. This was made up of chert breccia, cemented by a limestone matrix similar to that later described at the Headley mines; through the breccia the ore, consisting principally of blende, is disseminated. From the bottom of the shaft a drift was run to a distance of 50 ft. toward the west, and passed through thin, vertical crevices containing blende $\frac{1}{2}$ of an inch to 3 inches thick, parallel to the main vein; these were encountered across the whole length of the drift. Mr. Roote estimated that over 100 tons of cleaned ore had been mined here.

North of this shaft are numerous pits and shallow shafts, following the outcrops of the same or of closely parallel veins for a distance of about three-quarters of a mile, extending through what is known as the Tarbutton and Gaskill mines. From these diggings both 'silicate' and blende were taken. The course of the vein or crevice, as displayed in these diggings, is seen to be quite irregular; at the shaft, as stated, it was N. 20° W. (Mag.); while a short distance beyond this, to the north, it is N. 85° W.; southward, from the shaft to the diggings across the valley, which are thought to be on the same crevice, the course is S. 50° E.

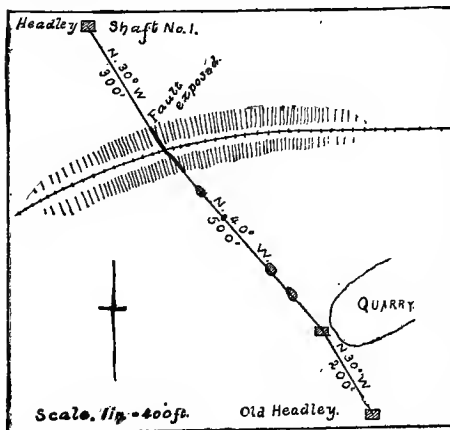


FIG. 188 Map of the Headley shafts.

Near the surface, smithsonite was found. Along the foot-wall, a clay selvage was seen. The length of this shaft was about 8 ft., the depth of the ore-bearing portion of the vein was about 20 ft., its thickness about 2 ft.; from this mass some 25 tons of ore had been obtained, which would yield, perhaps, 50 or 60 per cent of blende.

The Headley mines.—These mines consist of a number of openings on both sides of the railway track, about a mile west of Mansfield. The shafts were examined by the writer in December, 1893, and No. 1 was especially cleaned out for his inspection.

Headley Shaft No. 1.—This shaft is about 300 ft. north of the railway track. At the time of visit it was 51 ft. deep; about 20 ft. of this was through surface clay and debris; below this, a vein was struck 2 ft. thick, with a strike N. 30° W. (mag.), and dipping about 80° W.; the vein continued of this thickness to the bottom of the shaft, and contained blende from the depth of 30 ft. downward. The filling of this crevice consisted of a gray, calcareous matrix through which the blende was disseminated, sometimes so thickly as to make up a large part of the vein, at other times only in

Proceeding from this shaft S. 30° E. to the railway cut, the course of the vein is plainly traced, and, in the cut, the difference in character of the rock on each side of this vein shows that some faulting must have taken place. The plate opposite this page illustrates the conditions seen in this cut.

From here, to the next exposure southward, the course is S. 40° E., but thence to the old Headley shaft it is again S. 30° W., and the total distance of this shaft from the railway cut is about 700 ft. This shaft was 70 ft. deep, and the vein was here seen to be about 2 ft. thick. The contained ore was principally blende, with some little galena; smithsonite was abundant near the surface. These minerals are held in the usual limestone matrix. The dip of the vein was 75° W., and the strike N. 30° W. (mag.)

Headley shaft No. 2 is 600 ft. S. 23° E. from the last, and is about 76 ft. lower down the hill. The shaft was 32 ft. deep, and a vein of similar character and dip was encountered. Intermediate between these two shafts is one other shaft, in which Mr. Root says the vein was struck.

The old Headley shaft, it is worth while to note, is between 100 and 200 ft. lower than the Lead Hill mines previously described.

Between these Headley mines and the Berry shaft, diggings have been made at other points about half way between the two, but were not open at the time of visit. Among these are those on the McMullin farm, where a vein is reported to have been worked in a shaft 52 ft. deep, and also in shallow surface pits. From these there were mined, some years ago, as much as 50 car-loads of "silicate" and some 10 tons of lead ore. On land adjoining this to the west, diggings have also been made at points located on the map.

The Mansfield Mining Co.—On the eastern edge of the town, in the NE. ¼ of the NE. ¼ of section 21, a company by this name sank a shaft to a depth of 120 ft., at the bottom of which a body of lead ore 5 ft. thick is reported to have been struck. Opportunity was not afforded to examine this at the time of visit.

In conclusion, regarding these ore deposits of Mansfield and vicinity, they undoubtedly occur in veins along crevices, which are, in part at least, fault fissures. The exact amount of faulting cannot be stated without more detailed stratigraphic work in this region; from general considerations, however, we do not think the displacement has been great, and local observations bear this out: for instance, there is indubitable evidence of movement in the exposure of the railway cut, yet a few hundred feet south of this the rocks on both sides of the exposed vein seem to be the same. The opening of bodies of ore on crevices having a general northwestern course, and the fact that these openings are confined to a belt following that direction, does not in itself prove that they all are on the same vein; on the contrary, the minor differences in the courses of the veins as exposed at the various openings argue against this. It is probable that we have here a system of crevices and veins running parallel with each other along an axis of disturbance. Irrespective of these considerations, however, the questions as to the probable vertical extent of the ore deposits, and as to whether they will increase or decrease in richness with depth, all hang upon our solution of the general problems for the whole region, as to where its ores are derived from, and as to how they have been brought to their present positions. These questions we have attempted to answer in the preceding chapters, and, from the conclusions there given, we cannot logically say concerning these or other similar deposits in the state, that they may be counted upon to extend, or to continue of workable thickness and richness, indefinitely downward. On the contrary, though they may, and doubtless do, contain large quantities of ore within moderate depths, experience elsewhere and a careful weighing of all the facts in the case lead us to conclude that, as great depths are reached, they will become impoverished.

Beyond the immediate vicinity of Mansfield, a few other occurrences of ore are reported in the county. The most noteworthy of these are the Brazelton mines, of which Mr. Robertson gives the following description from observations in 1891:

Brazelton mines—These mines are situated about 7 miles northwest of Mountain Grove, on the Kansas City, Fort Scott & Memphis railway, in section 22, township 29 N., 13 W. Galena is the only ore mined, and this was found plentifully in the clay, from the surface to a depth of at times as much as 40 feet. Messrs. Brazelton and McEntire, of Mountain Grove, were sinking a shaft in the soft magnesian limestone for the purpose of prospecting the property.

At several points between Hartville and Marshfield are old clay diggings, said to have been worked by the Indians.

THE DADE COUNTY SUB-DISTRICT.

This sub-district is here made to include a small area of about 30 square miles, northeast of Greenfield, covering townships 31 and 32 N., to the north line of the district map, and ranges 25 and 26 W.

The surface rocks of this part of Dade county consist principally of the Burlington limestone and associated chert beds. Over certain areas, however, and especially in the vicinity of some of the lead and zinc mines, are remarkable deposits of chert conglomerate and red, friable sandstone, both belonging to the lower portion of the Coal Measure series. The Burlington beds are normally in a horizontal position, though in places slight dips are observable. The conglomerate and sandstone beds appear to occupy what were once great depressions in these altered rocks, though they also extend up to and over the present hill-tops.

Active lead and zinc mining in the county dates barely 20 years back, the first operations being in 1874. Since that time some 15,000 tons of ore have been produced. The principal mines of the sub-district have been the Corry, Old mines, New mines and the Pemberton mines. Figures of the output of these various mines during the earlier years of their operation will be given in the following descriptions. The following table illustrates what has been done here during the past five years :

PRODUCTIONS OF DADE COUNTY MINES.*

		Lead ore.		Zinc ore.	
		<i>Tons.</i>	<i>Values.</i>	<i>Tons.</i>	<i>Values.</i>
1889	Southwest M. Co. (Nixon)	80	\$1,260	174	\$2,088
	Shafer & Thurman (Corry)	25	1,200	.....	.....
1890	Four companies			1,647	17,296
1891	Allen & Hughes (Pemberton)			734	8,079
	Corry M. Co	87	4,200	25	250
	Southwestern M. Co. (Nixon)			163	1,626
	J. W. Thurman (McConnel).			352	3,696
1892	Corry M. Co	99	2,962	.....	.....
	Pemberton mines			63	667
	Southwestern M. Co			40	400
1893	Alder & Hughes			220	1,320

* From State Mine Inspector reports, years ending June 30.

The Corry mines.—These mines are situated principally in the W. $\frac{1}{2}$ of the NW. $\frac{1}{4}$ of section 30, township 32 N., 25 W. They were originally known as the mines of the Dade County Mining and Smelting company, were opened in 1874 and worked for about three years after that date. Many shafts and pits were sunk at that time, and furnaces for the smelting of the lead ore were erected. During this period about 1000 tons of pig lead and 5000 tons of smithsonite and calamine were pro-

duced. The output was all hauled to Dorchester, on the 'Friaco railway, over 30 miles distant. Some desultory mining was done between 1877 and 1891, and in the latter year the Corry Mining company was organized.

When visited by the writer in December, 1893, the diggings were strung along a hill-side in a north to south direction for half a mile or more near its summit; they were located along the edge of an outcrop of Coal Measure sandstone and conglomerate, which covers the country immediately to the west. The ore here, consisting principally of blende and smithsonite (though some calamine and some cerussite are also found), occurred in a brecciated mass of clay and much light-colored secondary chert, known as mineral rock. This ore breccia apparently follows along between the Lower Carboniferous limestone and the overlying Coal Measure conglomerate, just as we have seen it lying between the limestone and Coal Measure shale in "circle" diggings in Jasper and other counties. Most of the ore has been obtained from pits or shallow shafts, and one large chunk of galena, which weighed 25 tons, was found within three feet of the surface, according to Judge J. L. Shaffer, of Greenfield. During recent years, a shaft, known as the Patton shaft, was sunk on the hill-top, through the Coal Measure sandstone and conglomerate, with the hope of striking an ore body below it. The record of this shaft, as furnished by Judge Shaffer, is as follows:

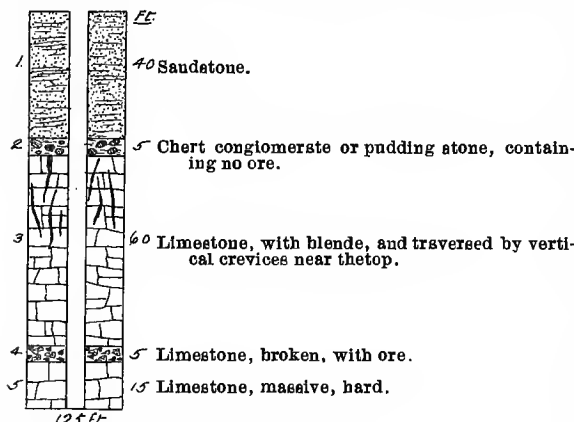


FIG 189. Section of the Patton shaft.

limestones of varying textures and colors for a total depth of 100 ft. After passing the first 15 ft., galena, blende and pyrite were found in seams and thread-like veins at intervals for the whole depth.

"Seventy-five feet east of the pump shaft, the first discovery of lead ores was made, the mineral being struck at a depth of 4 ft. The openings yielded 5 tons of minerals—galena and cerussite—the former predominating.

"At the King, Mathews & McDowell shaft, which had been sunk to a depth of 100 ft., the surface is 18 ft. higher than at the pump-shaft. The mineral was struck at a depth of 25 ft., and continued in greater or less quantity to 45 ft., when it disappeared entirely. On continuing the sinking of the shafts, seams of galenite were found in the rock at a depth of 65 ft., while at 82 ft., when the work was discontinued, the bottom was on a rock closely resembling in appearance that shown to me as having been met at about 70 ft. depth in the pump-shaft.

"It should be mentioned that, in most of the productive openings, masses of hard 'quartzite' are met, varying in thickness from a few inches up to, occasionally, six feet.

"Obviously the deposits in the neighborhood of Corry are confined to about the same horizon as are the zinc ores of New and Old mines later described, and extended openings horizontally are to be relied upon for maintenance of ore supply, rather than deeper mining.

"The zinc ores produced here are sorted to calamine* and blende varieties, and are hauled to Dorchester, on the St. Louis & San Francisco railroad. The lead ores are smelted in three rever-

These mines were examined by C. P. Williams in 1877, about the time of their active development, and the following unpublished descriptions by him of the Corry mines are extracted from manuscript preserved in the office of the Geological Survey.

"The vertical range of the lead and associated zinc ores seems to vary between 10 and 75 ft. from the surface, between which depths the bed-rock had been cut in the various shafts and diggings. In the pump shaft, it was found at a depth of 10 ft. from the surface, and the shaft had been carried down through

* 'The term calamine is used here in its metallurgical rather than its mineralogical sense, and includes both the silicates and carbonates.'

beratories of the common pattern and dimensions, belonging to the company. The operations of these furnaces, the characters of the galena put in treatment, and of the resulting lead, have been indicated in my previous Industrial Report for 1875-1876.

"Many of the openings yield handsome, though small, crystals of cerussite, of interest to the mineralogist."

Other zinc and lead mines in Dade county have produced large quantities of ores in the past. The principal of these were the Old mines, which were immediately southwest of the Corry mines, in the adjoining section; the Pemberton mines, in the SE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 36, about a mile south of Old mines, and a number of workings in the vicinity of section 15, township 31 N., 28 W., including the New mines. At one of these mines in section 15, over \$3000 royalty is said to have been paid to date, the rate being \$1 per ton. The Pemberton mines were shallow diggings in clay, and the yield was almost entirely "silicate." New mines and Old mines were both in operation, and were examined by Prof. Williams when he was in the county, and the following descriptions are extracted from the report above referred to:

"The New Mines.—These mines are located in the SW $\frac{1}{4}$ of section 16, in the E. $\frac{1}{2}$ of the SW $\frac{1}{4}$ of section 17, and in the SE. $\frac{1}{4}$ of section 17, township 31 N., 25 W. The section of the deposit struck in Howard's shaft is as follows:

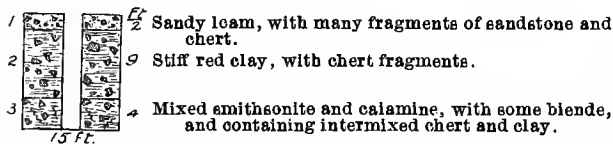


FIG 190. Section at "New mines."

5 ft. 3 in. thick was showing. The width of the drift was 6 ft. The diggings were worked by Mr. T. T. Howard, to whom I am indebted for a specimen of bournite found there.

"At Browning shaft, on the adjoining claim, and a few feet higher up the hill, the depth from the collar of the shaft to the bed-rock was 20 ft. The ore, similar in character to that found in Howard's shaft, was at a depth of 16 $\frac{1}{2}$ ft. Detached smaller masses of ore were found in the clay.

"Still higher up the hill, at Longwell's shaft, the ore was struck at a depth of 30 ft."

"In both these shafts, the bed-rock, so called, presents the same features as that cut in the Howard shaft. These characters continue the same for about 10 ft farther down, when the rock becomes more compact and hard, and contains fewer crystals of calcite. It shows occasional green stains of, probably, a silicate of iron, and a little pyrite, generally in small thread-like veins or seams.

"Old mines.—These are in the SE. $\frac{1}{4}$ of section 25, and in the N. $\frac{1}{2}$ of the NE. $\frac{1}{4}$ of section 36, township 32 N., 26 W. The surface at the diggings has an elevation of 156 ft. above the Sac river, half a mile distant to the south.

"The work was begun here nearly three years since, and about 1000 tons of high-grade calamine and smithsonite ores were taken out. An elliptical opening, of about 350 ft. and 175 ft. diameters, and with a maximum depth of 35 ft., represents the ground broken to recover the amount named. The locality is now particularly interesting from the series of experiments being made with a view to reworking this spent ground by means of the hydraulic system of mining.

"This work had been in operation for about two and a half months, and was, as mentioned, largely experimental. It appeared to be very effective, insofar as amount was concerned, for in that time nearly 1000 tons of good zinc ore had been recovered from the already worked ground. With regard to the cost of such work under the then existing circumstances, I am unable to form any correct estimate, for want of sufficient data.

"A vertical section of the rock exposed from the Sac river to the surface of the workings is as follows:

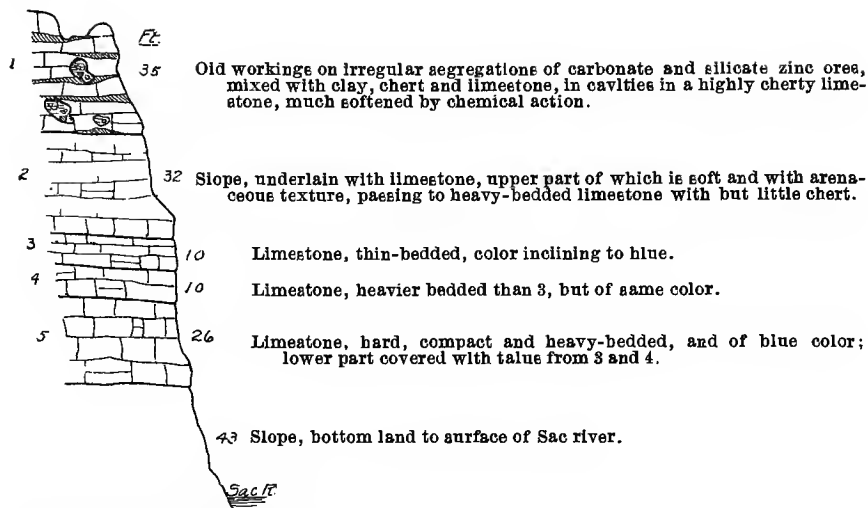


FIG. 191. Section at "Old minea."

"It is highly probable that the vertical range of the zinc ores at this locality, and at the New minee, is confined to the height above the upper part of No. 2 of the preceding section, and that it is varied more by the horizon of the surface than by any change in the dip of the underlying rocks, which are inclined to the southwest at a very gentle slope. If this be correct then the hopes of reaching a second run of mineral by deeper mines are not well founded."

In addition to these descriptions, Prof. Williams notes that zinc and lead ores are found in the following localities, though little work had been done at the time:

Township 32 N., 26 W., in sections 1, 12, 14, 23, 24, 25, 35 and 36.

Township 32 N., 25 W., in sections 7, 19, 31.

Township 31 N., 25 W., in sections 8, 9, 16, 17, 20, 21, 25, 26, 29, 30, 31 and 32.

Township 30 N., 25 W., in section 13.

Township 31 N., 27 W., in section 12.

OUTLYING DEPOSITS IN THE SOUTHWESTERN DISTRICT.

Outside of the deposits of the sub-districts thus far described, and partly beyond what we have taken as the limits of the Southwestern district, a few occurrences of lead or zinc ores yet remain to be noted. They are scattered over Stone, Taney, Ozark, Douglas, Texas and Howell counties, and occur almost entirely in the Lower Silurian magnesian limestones. The following notes were prepared in large part by Mr. Robertson :

STONE COUNTY.

This county is one of the few in Missouri that has no railroad facilities. The main line of the St. Louis & San Francisco railway runs just through the northwestern corner, while the Arkansas branch runs south some twenty miles west of the county. The surface of the county is extremely rugged in places, discouraging attempts at teaming and road-building, but in the valleys lie some very fertile farms.

Very little prospecting for either lead or zinc has been done in this county. Some small quantities of lead have been mined during several years past in the northwestern corner, and some prospecting has been done in the southwestern corner, as referred to on p. 622.

TANEY COUNTY.

King Solomon's mines.—Southwest of Kerbyville, about seven miles, in the NW. $\frac{1}{4}$ of the NW $\frac{1}{4}$ of section 26, township 22N., 21W., Messrs. Dayton, Anderson and others have prospected somewhat extensively for zinc. By means of a shaft 40 ft. deep, they have opened up a distinct crevice, which runs N. 50° W., and is traceable for 100 yards on the surface. The ore is largely calamine or silicate, of a fair quality, accompanied by blende of a light ruby color, disseminated in fine grains and crystals in the limestone breccia, which fills the crevice. The crevice was seen to be about 1 ft. wide at the surface, but is said to expand to 4 ft. lower down, though it opens and closes at intervals. The country rock is a very siliceous, compact magnesian limestone, sometimes carrying fossils.

In the SW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 15, township 24N., 22W., Dr. R. E. Montgomery has prospected for lead. Some ore has been found, but not sufficient as yet to permit of shipments being made. There was no work going on at time of inspection.

About Protom, in the southeastern corner of the county, specimen of lead and zinc ore are reported to have been found in nearly every forty-acre tract, but prospecting has been done at only a few localities. About five miles east of the town, in the S. $\frac{1}{2}$ of section 7, township 21N., 16W., which is strictly speaking in Ozark county, Mr. G. L. Holt sank two shafts to depths of about 30 ft., and obtained about 20 lbs. of lead ore, several tons of "iron ore" and about half a ton of zinc ore. The shafts were sunk on a nearly vertical opening, in which all of the ore was found. On adjacent land, other prospect shafts have been sunk and a little lead and zinc ore obtained.

About five miles northwest of Protom, at what is known as the Caldwell prospect, lead ore has been dug, and is described as occurring in pockets or vugs in the limestone without any clay associated with it.

OZARK COUNTY.

No mining for zinc or lead ores has been prosecuted in Ozark county, though both lead and zinc ores are known to occur at several localities. As early as 1856, Shumard noted the occurrence of galena in the county, in section 3 of township 21 N., 12 W., in section 33 of township 22 N., 12 W., and in section 17 of township 26 N., 13 W. At the localities it was found in the "Second" magnesian limestone, associated with calcite and sometimes with barite [33, p. 195]. In the northwestern portion, he also noted the occurrence of zinc ore.

In the southwestern corner, the Holt diggings, described under Taney county, properly belong to Ozark county.

TEXAS COUNTY (W. & R)

Very little lead or zinc mining has been done in this county, and the known occurrences of these ores are few, and are principally in the southwestern corner. They were visited by Mr. Robertson in 1891.

The Cabool Mining Company (R. & W.)—This company conducted the only noteworthy recent developments. The shafts are located in the SW. $\frac{1}{4}$ of section 1, township 29 N. 12 W., and are sunk through impure yellow limestone, blue clay and shale of probable Kinderhook age, these rocks occupying a limited patch of elevated country. The deepest shaft is about 90 feet. The ore consists of a good quality of "silicate," cementing together rounded fragments of limestone. More or less decomposed blende was noticed and, at a greater depth, it is possible that more may be found. These developments were made in 1889, according to information given by Mr. J. L. Goldsberry of Cabool, and in the summer of that year about 300 lbs. of lead ore from shallow diggings and $2\frac{1}{2}$ tons of zinc ore were taken out; the zinc ore from one shaft, between the depths of 30 and 40 feet.

In section 16 of township 25 N., 11 W., Mr. Goldsberry further informs us that prospecting was done during a number of years preceding 1889, and that considerable lead was obtained from shallow diggings.

In township 30 N., 10 W., lead is also reported to have been found at a number of places and some prospecting yielded considerable quantities of ore.

In past years some mining was also done about ten miles southwest of Cabool, near the extreme southwestern corner of the county and the occurrences are described by Mr. Gage in the report of 1873 and 1874, from which the following notes are extracted.

Brunet Diggings—These are situated in section 22, township 28 N., 12 W. Galena was found in an open cave 5 ft. high and 4 ft. wide, but which contracted and enlarged. The roof, sides and floor of this cave were covered by red clay, from a knife blade's thickness to several feet, continually deposited by dripping water. The cave was sinuous, and numerous smaller caves branched off at every angle. The country rock was considered the Third magnesian limestone. Several shafts were sunk in this rock, but no galena was found. Large crystals of galena are fastened to rock surfaces in the cave, and also occasional patches of soft hematite, together with stalactites and stalagmites of lime. At several other points in the neighborhood galena was found at shallow depths in clay.

The Lead Hill Diggings—These were located just south of the last, in section 27. A shaft, 12 ft. deep, was sunk through red clay and 4 ft. of magnesian limestone. This rock contains galena, sparsely disseminated through it, not over one per cent; at one point a narrow seam was traced for 20 ft.

HOWELL COUNTY (R)

But little prospecting has been done in this county. The iron interests overshadow the possible profits of lead and zinc, and, moreover, the larger portion of the citizens of this county are interested in fruit-growing and farming, and but little attention is given work outside of their particular business.

Lead and zinc occur here however. Specimens of very good silicate have been found within the corporate limits of the town of West Plains.

T. T. Luscomb & Company, of Carthage, Mo., have prospected to some extent in section 21, township 23 N., 10 W., about 15 miles southwest of West Plains, and immediately south of Dixon Springs. The country rocks are the Lower Silurian magnesian limestones. The ore is calamine, of a very good quality, cementing the fragments of limestone rock and lying in large masses in the surface clay, from a depth of 6 inches to 2 feet or more down to the solid rock, in which one shaft had been sunk about 10 feet in depth, without encountering any ore. The calamine was the principal mineral, though some little partially altered blende was noticed. Specimens of malachite accompanied the silicate, but very minute in size.

On Dry creek, in the SW. $\frac{1}{4}$ of section 23, township 25 N., 10 W., on land of H. Turner, some lead has been found, but no prospecting has been done there yet. A small crevice was noticed and could be traced for several feet, running N. 30° E. It was filled with galena.

On Capt. Wilson's farm, in the NE. $\frac{1}{4}$ of section 3, township 24 N., 9 W., some lead and zinc ores have been found, but no prospecting had been done at the time of visit.

CHAPTER XV.

THE MINES OF THE SOUTHEASTERN DISTRICT.

THE ST. FRANCOIS AND MADISON COUNTY SUB-DISTRICT.—THE WASHINGTON COUNTY SUB-DISTRICT.—
THE FRANKLIN COUNTY SUB-DISTRICT.

This district, as shown on the map, is made to include Perry, Ste. Genevieve, St. Francois, Washington, Franklin and Jefferson counties, the northern portions of Cape Girardeau, Bollinger, Madison, Iron and Reynolds counties and the eastern portion of Crawford county. The area thus defined includes all of the noteworthy deposits of lead and zinc ores in southeastern Missouri. Occurrences of ore exist beyond its limits, and some little prospecting has been done at a few localities; but the developments were small, and the amounts of ore obtained were insignificant and hardly deserve special consideration.

As with the southwestern, we have separated this district into sub-districts, both for convenience of description as well as because of certain differences in the deposits. Similarly, also, within these sub-districts, we recognize certain groups of mines, or camps, which are convenient units for description. The sub-districts recognized are as follows:

1. The St. Francois and Madison county sub-district.
2. The Washington county sub-district.
3. Franklin county sub-district.

Beyond the limits of these sub-districts are a few outlying ore bodies in Ste. Genevieve, Perry and Bollinger counties, which will also receive notice.

The Southwestern district is distinctively one of large mines where work is consolidated under one management. This is especially the case in St. Francois and Madison counties, where three or four mining companies have produced probably nine-tenths of the ore. The mines of these companies are, hence, by far the most important, and will receive extended notice.

THE ST. FRANCOIS AND MADISON COUNTY SUB-DISTRICT.

This sub-district includes, in addition to the mines of St. Francois and Madison counties, also those of western Ste. Genevieve county; it extends from the Bonne Terre mines on the north to Mine La Motte on the south, and eastward so as to include the Avon mines of Ste. Genevieve county. Disregarding the last group of somewhat outlying mines, the sub-district covers a territory extending about 5 miles each side of the Mississippi River & Bonne Terre railway, including thus the mines of Doe Run and Flat river; this is the area of the great bodies of disseminated lead ores, the mines of which have produced three-fourths of the output of the whole Southeastern district.

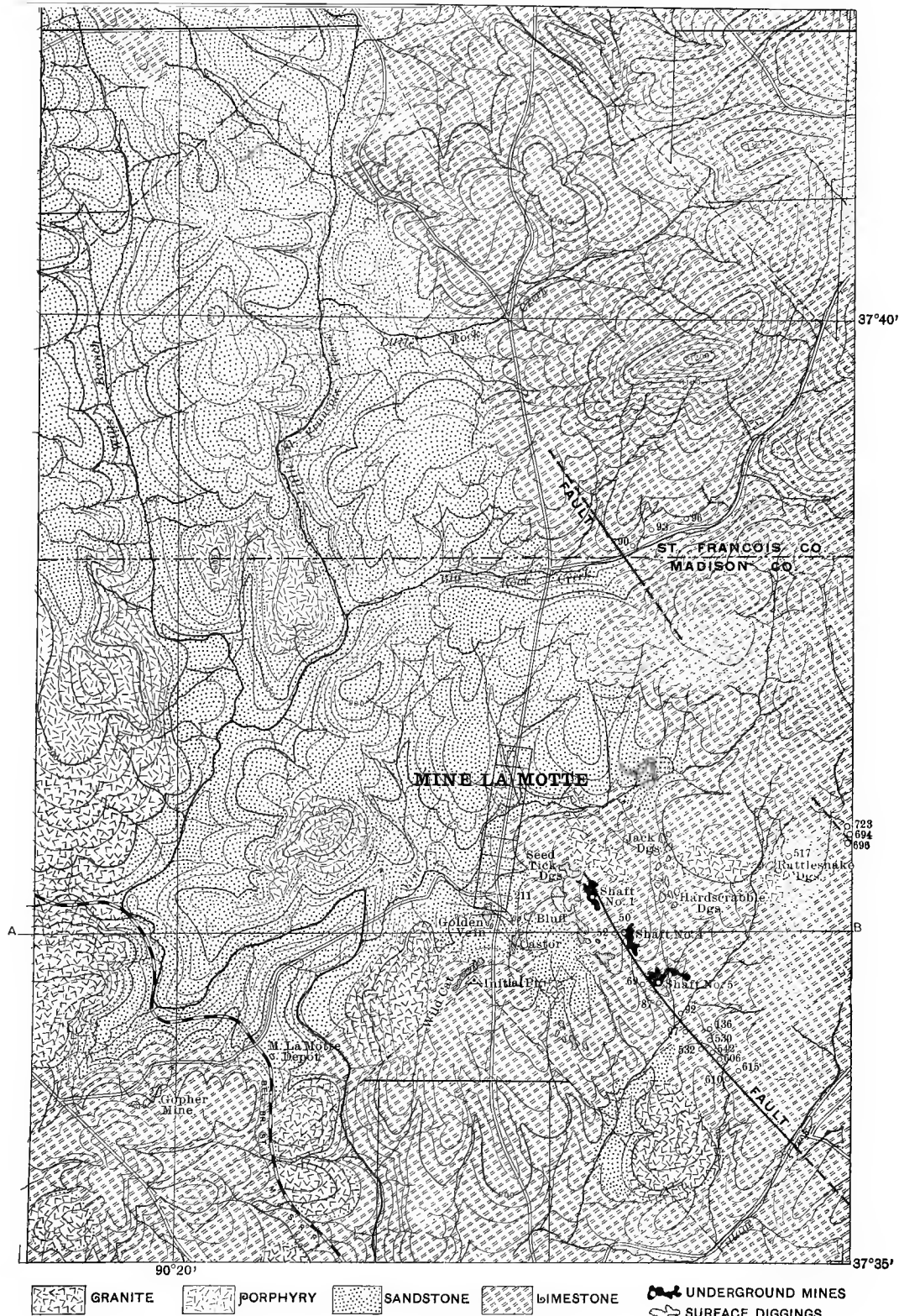
The history and statistics of these mines are so fully considered in preceding chapters and in what follows, that further reference to these subjects is unnecessary here. We proceed, therefore, at once to a description of the deposits as exhibited at the principal mines. These descriptions are based primarily upon our own observations, but we have also endeavored to make use of the results of our predecessors, who had opportunities for examination which do not exist now, and whose results are valuable supplements to the products of our more recent work.

In the sub-district we recognize five groups of mines or camps, as follows: 1) Mine La Motte mines; 2) the Bonne Terre mines; 3) the Doe Run mines; 4) the Flat river mines; 5) the Avon mines.

MINE LA MOTTE.

The Mine La Motte estate is a tract of nearly 40 square miles, situated about 25 miles from the Mississippi river in a southwesterly direction, and lying about two-thirds in Madison county and one-third in St. Francois county. The developed lead deposits occur over a tract of not more than 4 square miles in the southern-central portion of the estate, and are entirely in Madison county. These facts, as well as the topography of the greater portion of the estate, are shown on the map opposite the next page.

Topographically, the estate lies on the northwestern edge of the St. Francois mountains; it is traversed by the upper waters of the St. Francois river and its tributaries. The country is hilly, but not rugged; the hills generally have rounded profiles and gentle slopes, and, only along the larger streams, are bluffs of considerable height developed. The local differences in elevation are generally about 200 feet; the extremes of altitude are 720 and 1200 feet A. T. Much of the southern portion of the estate is arable land, and is under cultivation; that of the northern portion is largely wooded, and the country is somewhat rugged.



SCALE, $\frac{1}{82500}$ OR ABOUT 1 MILE = 1 INCH.
TOPOGRAPHIC AND GEOLOGIC MAP OF MINE LA MOTTE AND VICINITY.

From surveys by the Missouri Geological Survey.

HISTORY AND STATISTICS.

So much has been said in chapter VII relating to the past of this historic old mine, that it seems superfluous to add more on the subject here. We will, however, include the following brief notes, relating to the history of ownerships, which were collected by Mr. Robertson from personal inquiry, and from information given him by Mr. V. R. Allen, an old resident of the place, and once foreman of the mine.

Before the discovery of these deposits by the French, about 1720, they were known and worked by the Chickasaw Indians, from whom the early explorers first learned of their existence. From 1738 to 1744 the deposits were considered public property. In the latter year, Francois Valle received a grant of 2000 arpents (1668 acres, covering the part then worked) from the Spanish government, and eighteen years later he obtained some 28,000 arpents (23,833 acres) more, as a recompense for the killing of his son by the Indians. After the death of Valle the land passed to his sons Francois Valle and Jean Baptiste Valle and Joseph Pratt. The title to the land, which includes all of the present La Motte estate, was confirmed by Congress in 1827. In 1823 the owners of the land sold it to C. C. Valle, L. F. Linn and Everett E. Pratt. Two years later these gentlemen sold a portion of the property to Thos. Fleming & Son, and leased the remainder in lots of 40 feet square for a period of ten years. The Valles and Flemings sold the estate in 1868 to Scott and Lockwood, and shortly afterward a stock company was formed, and Rowland G. Hazard became a stockholder. About two years later Mr. Hazard bought the property in at a sheriff's sale, and, in 1875, turned it over to his son Rowland Hazard, who is the present owner. The estate comprises 23,954 acres.

Until 1873 mining was carried on in a very crude way, the developments consisting mainly of pits or shallow shafts sunk after the lead in the surface clay, or to strike the ore in the upper beds of the limestone. In that year, however, more systematic work was begun, namely, the sinking of shafts to the bottom of the ore deposits, and the regular exploiting of the ore, followed by a more careful process of concentrating and smelting.

Almost from the first years of its discovery, the mine has been a producer of lead, but to determine the productions of the 18th century, we have confessedly very few facts to go on. We know that work was in progress about the year 1723. Between the years 1738 and 1740, it is reported to have furnished almost all of the lead then exported, and it had apparently been worked quite constantly up to that time. Between 1740 and 1762, mining is recorded to have been only feebly prosecuted; while, in the year 1762, the mine was almost entirely abandoned, with the discovery of Mine a Burton, and work was not resumed until about 1790. In 1802, the production was at the rate of 100 tons per year; but it was then claimed as private property, and Austin states that the output was much less than that of the past. Mr. Mills, in estimating the production of the mine in his detailed report for the company [147], has allowed 100 tons of lead as an average annual output during the 18th century. All available facts considered, we think this a reasonable allowance and have adopted it.

For the years 1800 to 1819, we have Austin's statement in 1804, that the mine produced at the rate of 100 tons of lead per year between 1801 and 1804; for the 3 years 1817 to 1819, Schoolcraft allows an average of 400 tons of lead per year. Mills has taken the mean of these, 250 tons, as an average for this period, and we again follow him in accepting this figure.

For the years 1820 to 1829, there is a reference in the Public Lands' report of 1823, that during the preceding 3 years, Mine La Motte had produced about 500 tons of lead, or 167 tons per year. For the years 1820 to 1834, Mills allows 458 tons per annum. Later figures, given by Hodge [107], show an increase to about 500 tons in 1834. Therefore we have considered an allowance of 300 tons per annum for these 10 years as probably closer to the actual output.

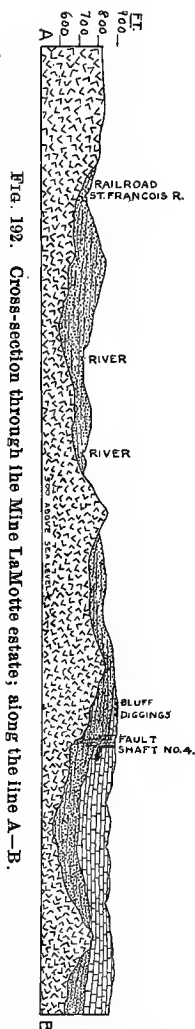


FIG. 192. Cross-section through the Mine La Motte estate, along the line A-B.

LEAD AND ZINC DEPOSITS OF MISSOURI.

Between the years 1830 and 1849, Hodge notes that, according to the certificate of the company, the production of the mine for the years 1834 to 1837 averaged 518 tons of lead per year. According to the same authority, the mine was actively worked in 1842. In 1838 the use of the carbonate very much increased the production. Mills allows for the 13 years from 1838 to 1850, 10,275 tons of lead, which is equivalent to 790 tons per annum. We have accepted this rate for the years 1838 to 1849, while, for the preceding 8 years, we have taken 500 tons per annum as an annual allowance.

During the years 1850 to 1859 little work was done, because of litigation. In 1852, Whitney states that not over 20 men were employed, and the production was not more than 50 to 100 tons. For the years 1851 to 1861, Mills allows a total production of only 700 tons of lead, equivalent to 58 tons per year. We have accepted this rate for the 10 years of our period.

For the years 1860 to 1869, there are the following figures, extracted from Mills' report:

	<i>Tons lead.</i>	
1861 to '63 (3 years).....	2,730	Mills & Allen.
1864 to '67 (4 years).....	3,276	Mills & Allen.
1868 to '69 (2 years).....	3,006	Gage.....
Total	9,012	
For 1860 we allow.....	448	
Total.....	9,500	

During the period 1870 to 1879, Mr. Mills furnishes figures as follows:

	<i>Tons lead.</i>
1870 Iron Mt. R'y shows	2,564
1871 Office books show.....	1,801
1872 " " "	1,411
1873 " " "	1,481
1874 " " "	1,232
1875 " " "	2,324
1876 " " "	2,914
Total	13,677

In addition, we have the returns of the Tenth Census for the year 1880, which give a production of 3581 tons of ore from Madison county, equivalent to about 2500 tons of lead. Further, Mr. J. D. Sanders, superintendent of the Mine La Motte, informs us that the total production for 1877 to 1890 inclusive (14 years), was 35,591 tons of lead, equivalent to 2544 tons per year. We, hence, allow for the three years, 1877 to 1879, 6323 tons, which, added to Mills' total, gives 20,000 tons for the decade.

Our allowance for the 14 years of 1880 to 1893 is based upon the following data:

	<i>Tons lead.</i>
1880.... Tenth Census gives 3581 tons of ore	2,500 (about)
1884a .. Estimate State Mine Inspector (Rep. 1887)	3,800
1885.... W. B. Cogswell to State Mine Inspector	3,047
1886a .. State Mine Inspector (Rep. 1887).	3,800
1887a .. State Mine Inspector "	4,480
1888a .. State Mine Inspector.....	3,000 (about)

a For the year ending November 5.

		Tons lead	Values.
1889 b..	State Mine Inspector	3,715	\$284,569
1890 b..	State Mine Inspector	3,033	239,091
1891 c..	From J. D. Sanders.....	3,337	.....
1892 c..	From J. D. Sanders.....	2,987	.....
1893 c..	From J. D. Sanders.....	2,487	.....

b For the year ending June 30.

c For the year ending December 31.

From the total production furnished by the company, we conclude that the figures given by the State Mine Inspector for the years 1884 and 1888 are probably inaccurate. Since that time, however, they have been quite carefully collected. In determining the total production, we therefore use the company's figure of 29,268 tons (35,591—6323=29,268) for the 11 years of 1880 to 1890, and the company's figure of 8851 tons for the years 1891, 1892 and 1893.

The total amount of lead obtained from the Mine La Motte ores from the beginning of operations to the end of the year 1893 is, hence, as follows:

1720 to 1790, production of lead	8,000 tons.
1800 to 1849, " "	21,485 "
1850 to 1893, " "	68,219 "
Total.....	97,704 "

The sales of this lead at prices prevailing during the various periods must have yielded very nearly ten millions of dollars.

GENERAL GEOLOGY.

The geological formations within the limits of the estate consists of Archean granites and porphyries, traversed at three or four localities by pre-Silurian dikes of diabase, and of Lower Silurian magnesian limestones, sandstones and cherts.

Archean.—The Archean granites are of the common "red" variety, consisting essentially of ordinary quartz grains and of light-red feldspar, with black mica more abundant as the principal accessory than is generally the case in the rocks of the surrounding country. In texture, it is sometimes coarsely granular, but is usually fine-grained, approaching the porphyritic. The porphyries are of reddish brown colors, essentially of the same composition as the granites (*i. e.* consisting of quartz and feldspar), but without the mica as an accessory; they are normally of a dense, porphyritic texture, but in places are more coarsely grained and grade into the granites. The dikes are of what Mr. Haworth terms diabase porphyrite. These rocks, as shown on the map opposite p. 647, are confined to the southern portion of the estate, where they exist as tongues and outliers of the large Archean area to the southwest.

Lower Silurian.—The Lower Silurian rocks consist of a basal sandstone, which we call the La Motte sandstone, and of an overlying series of magnesian limestones. These rocks, in the southern portion of the estate, occupy the estuary-like spaces between and around the promontories and knobs of Archean rocks, and they cover the northern portion exclusively.

The basal sandstone is the same as that already described as generally underlying the St. Francois limestones. It is exposed at a large number of localities, but especially in proximity to the Archean rocks, between which and the limestone it spreads in a sheet of varying thickness. It is generally soft and friable, sometimes white, but often yellow or brown, especially where exposed at the surface; it frequently exhibits false bedding. The approximate limits, as exposed over the tract, are shown on the map, but the difficulty of drawing a sharp line where there is really

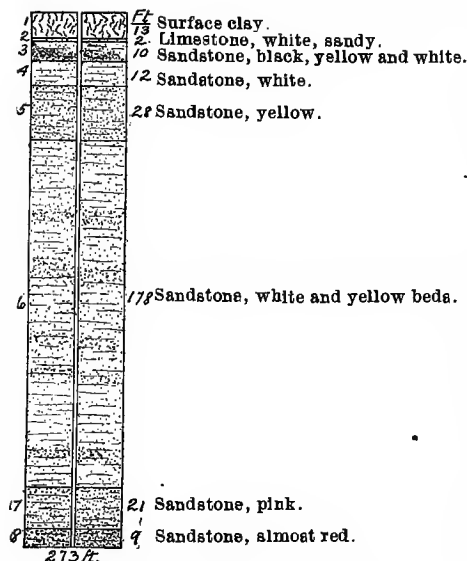


FIG. 123. Record Drill-hole No. 211, Mine La M. Co.

Chert group, some 270 ft. thick.

Massive magnesian limestone group, estimated 135 ft. thick.

Lead-bearing group, 76 ft. thick.

To the chert group he assigned the beds from which the residuary chert, so abundant over the "Flint hills" of the northern part of the tract, was presumably derived; few exposures were observed, and these were thinly bedded, siliceous, yellow limestones, none actually containing the chert. The Massive magnesian limestone group he recognizes as consisting of massive beds, compact and uniform, light gray near the top and darker and sometimes sandy near the bottom; neither of these groups contain lead ores, except perhaps in scattered masses.

The *Lead-bearing group* is principally magnesian limestone, which he divides again into two sub-groups. The upper of these, 22 ft. thick, as exposed about the mine, is more or less argillaceous and dark-colored throughout, and contains layers of blue to black slate, the well-known *lingulella* beds. At the bottom of this sub-group he places the so-called "Jack" ore-bed, in what is now called the "Black rock" by the miners. The lower sub-group, 54 ft. thick, is of a gray color, more arenaceous, containing white grains of quartz, and varies from a limestone to a quartzite; it is also sometimes green, with a chloritic mineral. The "Bluff" ore-bed is placed about 25 ft. from the bottom of this sub-group, in the "White rock" of the miner.

These characteristics prevail in the vicinity of the mines, and, probably to a great extent, east of them to Village creek. West and north of the diggings, Mr. Mills considers that the limestone is largely replaced by sand, so that we have a barren sandstone belonging to the Lead-bearing group, in place of the limestone elsewhere. Mr. Mills distinguishes this sharply, however, from the basal or lower sandstone, and separates the two on his map. The lithological differences between them, he states, consist in the presence of grains or even of fragments of feldspar and of chlorite, and of the absence of false bedding in the sandstone of the Lead-bearing group. To us it seems that we have here only another instance of lateral change from sandstone into limestone, which we have described as common elsewhere in the district, and we see no good reason for separating this sandstone from the basal sandstone. Fragments and decayed remnants of Archean

a gradation, as explained farther on, prevents this being more than approximate. The full thickness is not known, but, at one point, a drill-hole was sunk 258 ft. in it without reaching the bottom. The accompanying record is of this hole, which is located on the map. No lead ore is found in this sandstone.

The *magnesian limestones* belong to the St. Francois formation, and are also of the nature of those prevailing throughout the district: i. e., they are crystalline, granular, occur in thin and massive beds, contain more or less shale, especially in the lower part, and are often arenaceous near the base. They are found principally in the northern portion of the estate. The total thickness represented here is probably not far from 600 ft. Mr. Mills, who had excellent opportunities for detailed examination, and who is a close observer, found reason, for the purposes of his report to the company, to divide the series into three groups, as follows, from the top downward:

rocks are common elsewhere in the latter rock, and their presence, as well as false bedding, is dependent more upon location with reference to Archean outcrops (as is shown on the map) by the distribution of the sandstone and to the course of currents, than upon stratigraphic position. Our

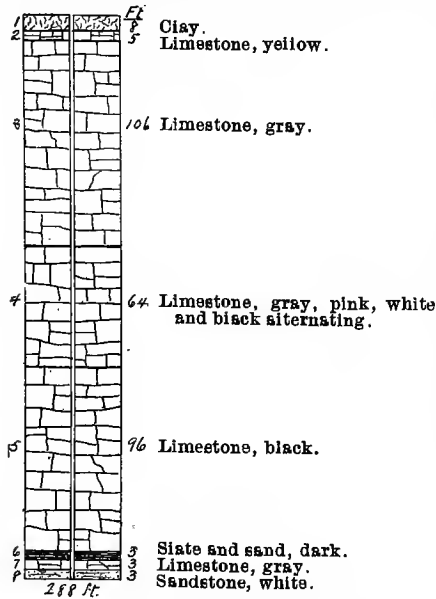


FIG. 194. Record of drill-hole No. 93, on Big Rock creek. N. 13,160 ft., E. 5445 ft. of Initial point.

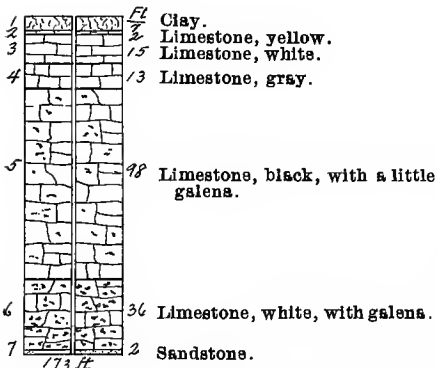


FIG. 195. Record of drill-hole No. 136, southeast of shaft No. 5. S. 2015 ft., E. 7170 ft. of Initial point.

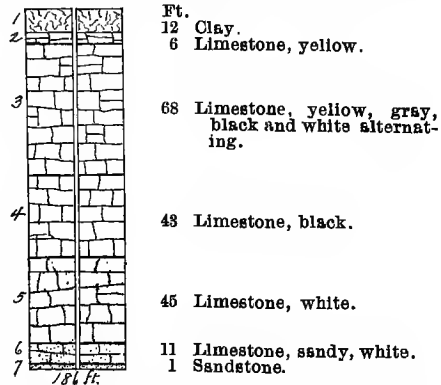


FIG. 196. Record of drill-hole No. 615, southeast of No. 136.

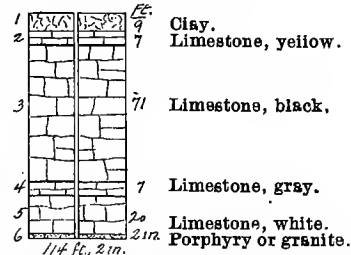


FIG. 197. Record of drill-hole No. 577, northeast of Rattlesnake diggings. N. 3745 ft., E. 10,075 ft. of Initial point.

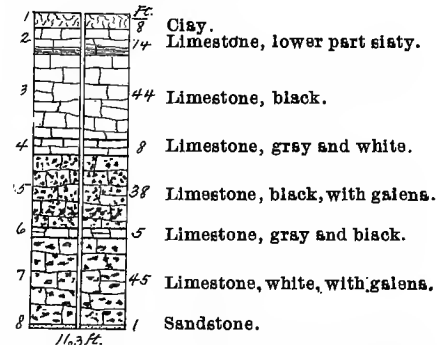


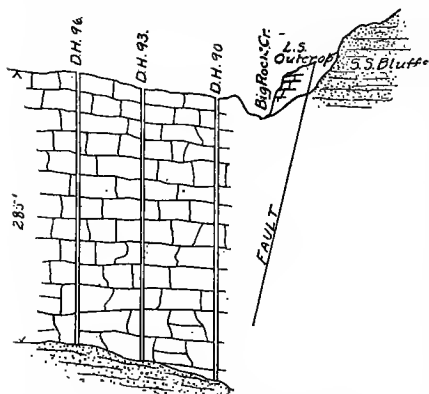
FIG. 198. Record of drill-hole No. 530, close to No. 136. S. 2505 ft., E. 7,195 ft. of Initial point.

own observations on the ground, though avowedly less extended and less thorough than Mr. Mills', revealed no stratigraphic break between the two sandstones of areas which he separates from each other, and we were unable to discover his structural reasons for such separation. That certain

sandstone strata here belong to the same horizon, or were deposited contemporaneously with certain beds of limestone, is undoubtedly a fact, but, in such details of stratigraphy, we deem it impracticable to draw even approximately correct division lines on any other than lithological differences.

Sections.—The sections of the lower portion of the magnesian limestone series, as exhibited at various points over the tract, are displayed in the records of drill-holes on p. 651, whose locations are shown on the map:

Flexures and Faults.—The attitude of these Silurian rocks is essentially horizontal, though gentle dips of a few degrees are detectable almost everywhere. Adjacent to the Archean rocks, the rocks dip away from them, following the original slope of the floor. Mr. Mills recognized certain axes of gentle flexures, the principal system running NW.-SW., the other approximately NE.-SW. The general result of these he describes as one great anticline, the axis of which is NW.-SE., and which plunges to the SE. From the fact that the axes of the minor flexures, as



located on his map, are across and along the Archean outcrops, we are of the opinion that the dips consequent upon a sloping floor have, in part at least, been taken as evidence of flexing; the distribution of the Archean rocks is such that the combined effect may have given rise to a belief in the presence of a great anticline traversing the tract from NW. to SE.

The presence of faults with a NW.-SE. trend is plainly recognizable both in the mines (where they will be described later) and elsewhere. Mr. Mills locates three, traversing the northern part of the estate, between one and two miles NE. of the mine. One of these, which he calls the "Great" fault, has been proved by drill-holes 90, 93 and 96, located on the map, to have a throw of at least 300 ft., the uplift being on the south.

The adjoining cut, from a sketch on the ground, well illustrates the conditions here. The record of drill-hole No. 93 is given on p. 651, the other two are similar. Mills describes the faults as passing into synclines toward the southeast, but continuing as faults toward the northwest. Drilling in the summer of 1894, in the extension of this great fault, gave somewhat peculiar results. Holes Nos. 696, 694 and 723 were put down, northeast of the Rattlesnake diggings, as located on the map. The first reached hard "red porphyry" at a depth of 75 ft. No. 694 passed through the following materials, according to the superintendent, Mr. J. D. Sanders, who kindly supplied the information:

	Feet.
1. Clay.....	10
2. Limestone, yellowish at top, then black, gray and white in irregular layers of varying thickness	458
3. Reddish-gray rock, consisting of fragments of feldspar imbedded in a siliceous limestone.....	9
Total.....	477

In drill-hole No. 723 were encountered:

	Feet.
1. Clay.....	27
2. Limestone, yellowish, sandy	59
3. " " black, gray and white, like 2 of No. 694, black predominating.....	685
4. Sandy rock, some lime at top, but getting more sandy, with quite pure, very hard sand at bottom	23
Total.....	794

The drop of the "porphyry" between holes 696 and 694 is so sudden and great (amounting to at least over 400 ft., within a distance of only about 300 feet) that it is probably due, in part at least, to faulting. It is possible, however, that a steep slope of the Archean floor, such as are recognized elsewhere, augments the apparent throw considerably.

THE ORE DEPOSITS.

The great bulk of the lead ore consists of galena disseminated through limestone, sometimes so densely and abundantly as to constitute the major portion of the rock, elsewhere only in scattered grains; some ore is, however, also found in vertical crevices (of which the "Golden" vein was one), and also in cavities enlarged by solution. Before 1865, a good deal of ore was taken from such openings, but the disseminated ore was long before then the principal source of supply, and Featherstonhaugh describes it as being quarried out in 1836. Galena is also disseminated through sandstone in places, into which the limestone frequently grades, though it is less abundant in the sandy portions. During the earlier surface work, a good deal of cerussite was obtained. The disseminated ore is recognized as occurring principally at two horizons, but in these the ore varies in quantity, being most abundant in rocks of open, porous texture, and also in portions that are traversed by faults and crevices. The limestone of the upper horizon is known as the "Black" rock, of the lower as the "White" rock; the ore is more persistent in the White rock, and toward the east the Black rock becomes gray. These rocks differ merely in color from contained iron or other impurities, and are, hence, not always separable. As developed by recent drill-holes, they are found to have an aggregate thickness of from 70 to 144 ft., sometimes separated by about 15 ft. of gray limestone. They correspond to Mills' upper and lower sub-groups. They dip slightly to the east, away from the Archean area, cropping out near the western limits of the limestone, as shown on the map. Along these outcrops the early shallow diggings were distributed.

In the Black rock, near its base, is the upper ore bed, which Mills termed the "Jack" bed. The thickness he found to be normally 7 ft., but sometimes as much as 11 ft., and above this, for 6 or 7 ft. more, galena is found in films along joint-planes and crevices, and also in bunches. The available galena from the bed as developed up to the time of Mills' report was equivalent to a solid layer averaging 2.55 inches in thickness. Associated with this bed, most of the copper and iron pyrites carrying nickel and cobalt, were found, which, intermixed with the galena, occupied large, flat, lens-shaped portions of the ore body.

The White rock carried what Mills terms the "Bluff" ore bed. He defined it as occupying a position 15 to 30 feet above the base, but later developments show it often near the top of the White rock, so that the two ore beds are sometimes in contact. The thickness is generally about 7 ft., but ranges from 5 to 11 feet. About 40 per cent of the entire area of the bed had been profitably worked up to the time of Mills' report, and the average thickness of the workable portions he estimated to be 1.4 inches. Some oolitic silica was recognized by Mills in this rock, and the writer has observed that it is often very sandy; it also contained some chlorite and calcite; comparatively little copper or iron pyrite are found in it, excepting at two or three localities.

The principal mineral associates are calcite, iron and copper pyrites, and the rare cobalt-nickel sulphides; galena, calcite, dolomite and pyrite crystals are found lining small cavities, and also along crevices; calcite is also found in large crystalline masses imbedded in the limestone.

The galena occurs normally disseminated through the solid rock in crystalline grains or small masses. The distribution is sometimes uniform throughout the face of rock exposed; elsewhere the mineral is abundant about certain centers; and, again, the grains of galena are frequently strung out along the stratification, sometimes so close together as to form sheets, which vary in thickness from one-tenth to several inches. These conditions are well illustrated in fig. 200. The limestone at the contact is entirely unaltered, and the galena is bright and unchanged on fresh fracture. Where the limestone is sandy, grains of rounded quartz are found imbedded in the galena, showing that, though the limestone has been removed, the quartz has remained. We have in these ores, undoubtedly, a case of metasomatic replacement.

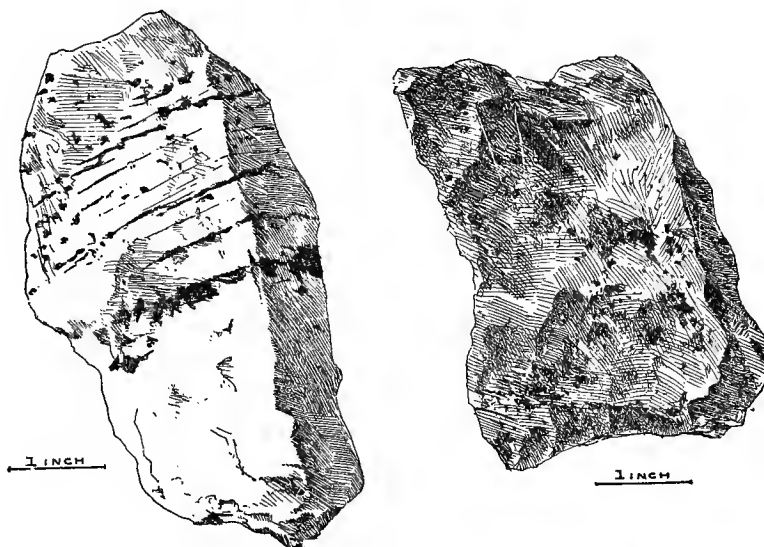


FIG. 200. Disseminated galena in magnesian limestone.
 Sketched from hand specimens from southeastern Missouri, by S. J. Hitt.

Descriptions of Mines.—The distribution of mining in the past and present is clearly shown on the map of the property. The diggings and shafts are there seen to be confined to a limited tract of only a few square miles. It is to be noted that they are in that portion of the limestone which lies nearest the Archean area to the west, and that they are also densest immediately about the outlying granite outcrops or knobs. The mines were examined in some detail by the writer in the summer of 1892, and the following descriptions illustrate the condition of mining and the underground phenomena as then observed.

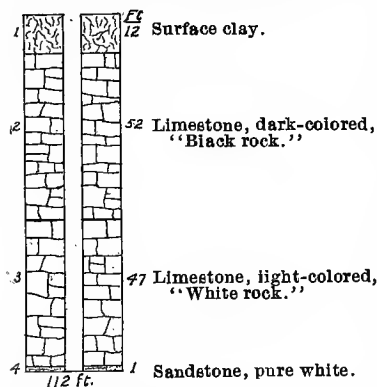


FIG. 201. Record of Shaft No. 1.

was seen having a NW. course, and accompanied by an offset indicating a throw of a foot or two. At the face, or end of this drift, the roof was wet and dripping, and the rock soft and iron-stained, and contained also numerous cavities. These cavities were a foot or more in diameter at times,

Shafts 1 and 2.—These shafts operate the westernmost of the large underground mines recently developed; their locations are shown on the map opposite page 647; from these shafts the workings extend about 600 ft. north and 400 ft. southeast. The section at shaft No. 1 is as shown in adjoining figure.

The galena was found here in both White and Black rocks. On the opposite page is a map showing the extent of the underground workings on January 1, 1892. This map is reproduced from the company's mine map, though all pillars and other details are omitted. The locations of the shafts and fault-lines which cross the workings are however shown. These faults and crevices were especially studied underground by the writer, inasmuch as they have undoubtedly influenced the distribution of the ore. At the mouth of what is known as the Prospect drift in this mine, a crevice in the rock

though others were considerably smaller; they contained clay, and also crystals of calcite and pyrite; they were sometimes of flattened and oblong shapes, and one prominent one had a NE. course. Joints were visible in the roof at this point, running NW.

What is known as the Main fault is encountered in these workings at the lower level, near the western end. It was there seen to strike N. 62° W. and to dip 80° NE.; the ore is faulted, the drop being about 10 ft. down on the north side. Adjacent to this fault the rock was rich in galena on the south side; it was here of open texture, containing small cavities lined with calcite and galena crystals, and these were also found along narrow crevices which traverse the rock. Crushed fragments of rock, rounded and smooth surfaces, were visible along the fault-planes. This fault can be traced for a distance of about 300 ft. Proceeding northeast from it, the rock rises at an angle of about 5° , and gradually changes into a sandstone, consisting of well-rounded, minute grains of quartz, cemented by lime and a greenish chloritic substance; in this are small lenticular sheets of limestone, though sometimes such are almost entirely absent.

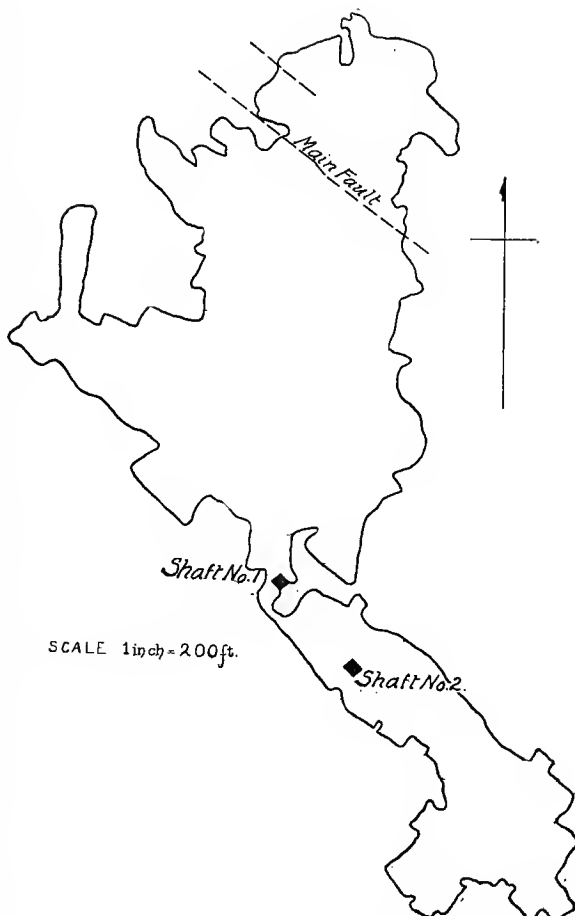


FIG. 202. Outline of area worked from Shafts Nos. 1 and 2, Mine La Motte.

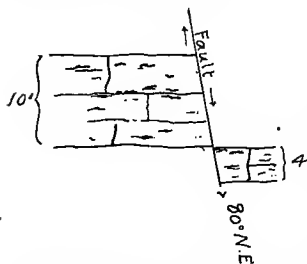


FIG. 203. Main fault in Shaft No. 1. in a trough-like depression.

In the upper level of this mine, in the Black rock, the same fault is found with the same dip to the northeast, locally with a strike N. 50° W. A thin (6 in.) bed of shale or slates here showed clearly that the throw is about 5 or 6 ft. A "chimney" enlargement of the fault fissure was exposed here, constituting a "mud opening." Near the top of the drift a horizontal crevice was traceable, along which water flowed, and which was stained red with iron. A good body of ore was found here contiguous to this fault on the south side.

At the lowest level of the mine quite a body of copper pyrite, carrying nickel and cobalt, was found under the lead ore body,

Shafts Nos. 3 and 4.—These shafts operate the mines next east of shafts Nos. 1 and 2. A section of No. 4 is as follows:

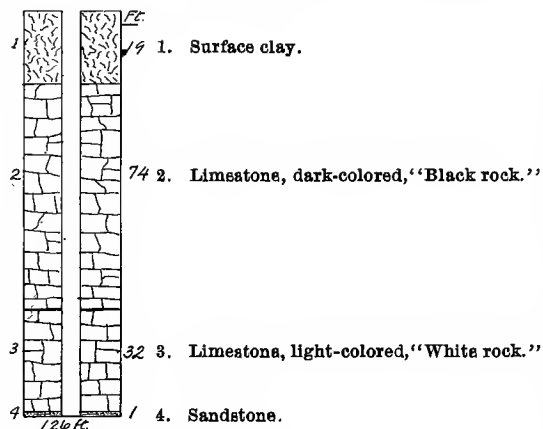


FIG. 204. Record of shaft No. 4.

The ore was found here in both the Black and White rocks, mostly near the contact of the two, and thus the ore bodies are close together. The map of figure 205 shows the extent of operations. The prevalence of crevices is also to be noted, as well as their somewhat varying courses. At shaft No. 3, the ore body is not more than 35 feet from the surface, but it dips quite strongly thence to the NE., and at the air shaft it is already 82 feet deep; thence, north-eastward, it continues to descend, largely by a series of steps or faults which are represented on the map. These faults and crevices were studied with especial care in the mine, and figure 206, of a cross-section

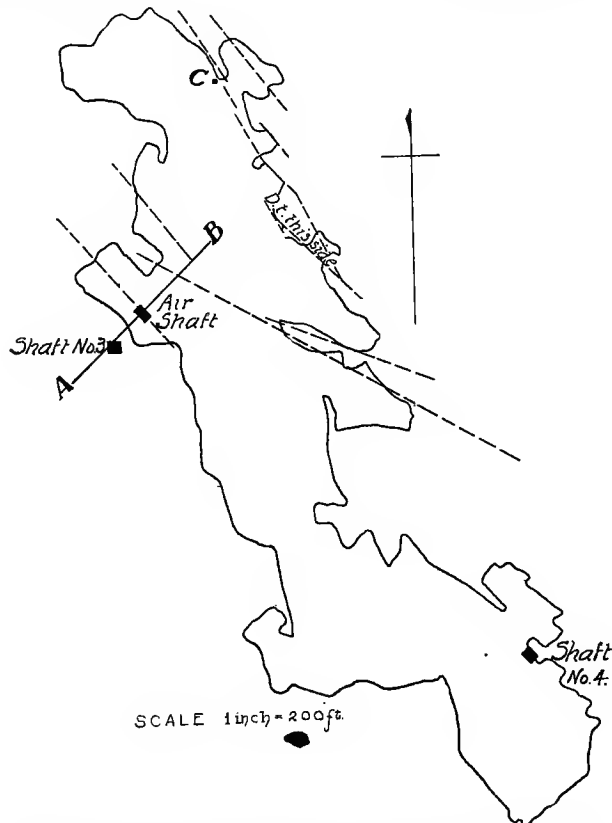


FIG. 205. Outline of area marked from shafts 3 & 4, Mine La Motte.

along line A-B on the map, illustrates the observed conditions. A peculiar fact about these faults is that they cannot be traced far laterally in the mine; thus, of those represented in figure, only the one marked X is recognizable in the drift to the southeast, which is only 150 feet distant; the others had vanished. At the end of the tramway in this mine, at the point marked C, is one large fault and several minor ones, which are shown on the map. Figure 207 is a cross-section at this point. The adjacent rock is open and vesicular; galena occurs crystallized along narrow crevices, together with dolomite, and it is associated with large, crystalline masses of calcite.

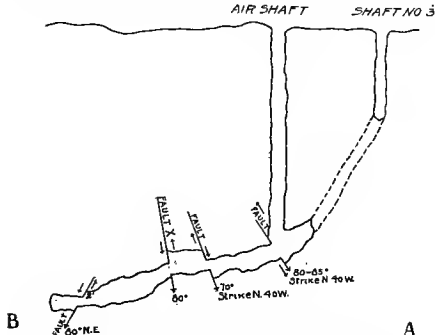


FIG. 206. Cross-section along line A-B.

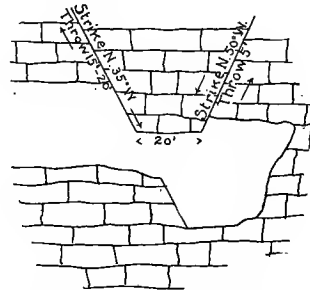


FIG. 207. Cross section at C.

Shaft No. 5.—The workings of shaft No. 5 were not accessible at the time of visit. We can, hence, only present the map of p. 658, obtained from the company's records, and the following section of materials passed through in the shaft.

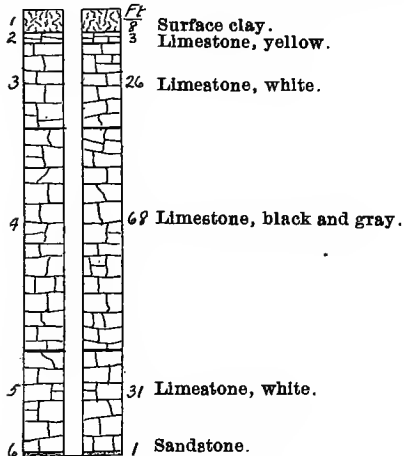


FIG. 209. Record of shaft No. 5.

amounts to much more, as is shown by the depths at which the basal sandstone is encountered in the different drill-holes. From these it would appear that the throw at some points must be at least 150 ft. The following table of p. 659 shows this very plainly. In it the opposite drill-holes on each side of the fault are arranged in separate columns, and the depths at which the basal sandstone was encountered are given.

As suggested by Mr. Sanders, the superintendent, it is probable that this fault is composed of a series of small throws or step-faults, as is shown in shafts Nos. 3 and 4. The disturbance apparently increases westward from shaft No. 1; how far beyond the limits of the property it extends we are unable to say.

The ore was found principally in No. 5 of this section, at depths of 123 and 135 ft.

The Main Fault.—We have already made mention of what is called the Main fault which traverses the workings of Nos. 1 and 2 shafts in a northwest to southeast direction. This fault is traceable southeastward to the limits of the property, and is located on our map. A number of drill-holes have been sunk on both sides of it at different points, and, in the bed of Village creek, a shattered exposure of limestone is to be seen, with slickensided surfaces, which marks the line, though no one prominent break can be recognized, and no crevice exists there. That this fault has some influence on the distribution of the ore is doubtless true, but what this influence has been is another question. As is plainly seen in the mine, the throw along it amounts to only a few feet, at least in mines Nos. 1 and 2. West of this, however, the throw

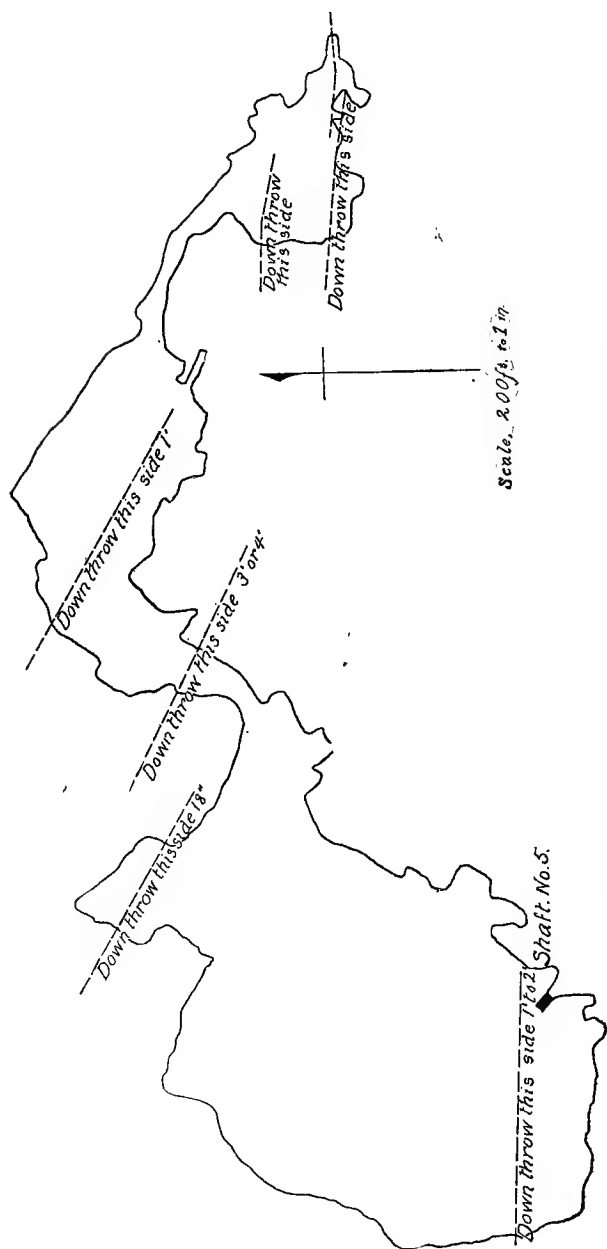


FIG. 208. Outline of area worked from shaft No. 5, Mine LaMotte.

DRILL-HOLE RESULTS ALONG THE MAIN FAULT.

<i>West of Fault.</i>			<i>East of Fault.</i>		
Drill-hole No.	Surface Alt.	Depth to S. S.	Depth to S. S.	Surface Alt.	Drill-hole No.
	<i>Feet A. T.</i>	<i>Feet</i>	<i>Feet.</i>	<i>Feet A. T.</i>	
52	.....	37	70	.....	50
69	.....	31	.....	.....	.....
87	.....	42	.....	.....	.....
.....	.....	.....	126	.....	92
97	810	14	171	820	136
532	830	18	161	820	530
.....	.....	.....	143	.....	542
.....	.....	.....	136	835	606
610	840	71	185	840	615

It was hoped after Mills' report, that the ore bodies would be found to extend, if not of undiminished richness, at least in workable condition, eastward to the limits of the property. Since that time much shafting has been done and many drill-holes have been sunk, and the results show that the quantity of ore is diminishing eastward, along with changes in the character of the rock.

The Copper Mines.—In the extreme southern-central portion of the property is what is known as the Copper mines, located on the map. The deposits here consist of a bed of limestone, heavily impregnated with copper pyrite. The principal bed was from 10 to 18 inches thick, but above this, according to Whitney, the limestone, to a thickness of 8 ft., contains copper pyrite along small fissures, the whole constituting a large lenticular ore body a few hundred feet in diameter. Under the main ore body is sandstone, the upper few feet of which Mills placed in his Lower lead group, and at the horizon of the Bluff bed. No work has been done at these mines for some years, and opportunities were not afforded for inspection at the time the locality was visited.

OTHER OCCURRENCES OF LEAD ORE IN MADISON COUNTY.

In the limestone valley about Fredericktown, a great deal of diamond drilling has been done during recent years, in the hope of finding ore. Holes have been put down to depths of several hundred feet, and, in all that have reached the base of the limestone, sandstone has been encountered, according to notes kindly furnished the writer by Mr. Frank Schulte of Fredericktown. Limestone openings are frequently encountered which contain clay and sand, and which prevent further drilling. Recently, a good deal of such prospecting has been done in lot 4 of the NW. $\frac{1}{4}$ of section 1, township 33 N., 6 E., about three miles northwest of Fredericktown. The following results were furnished by Mr. Schulte:

In the overlying clay, through which pits are dug preparatory to drilling, manganese or wad is often found associated with red clay or loamy ocher, at depths varying from 30 to 60 ft. The wad occurs up to one foot in thickness, but thin streaks are also found running through the clay. The limestone under this, Mr. Schulte says, is always lead-bearing. No residuary chert is found resting on the limestone, though above the clay is generally a layer from 3 to 6 ft. thick of such chert. Tallow clay, both red and yellow, is found in the same pits with the manganese; the latter never lies directly on the limestone. In one place the superficial clay is at least 112 ft. thick, and the bottom had not been reached then. In this lot about 24 drill-holes had been put down, and sufficient galena has been found to warrant the sinking of a shaft; sandstone is often found at the bottom of many of these holes, the deepest at 132 ft., at a point high up the hollow.

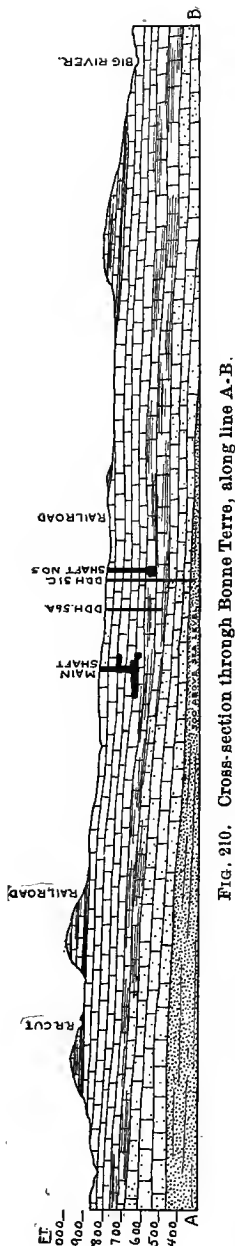
THE BONNE TERRE MINES.

The mines of Bonne Terre are the property of the St. Joseph Lead company, and include what have been called the LaGrave mines and the Desloge mines, the latter known in earlier days as the Pratt mines. They are located about 50 miles south of St. Louis and 20 miles from the Mississippi river, on the Mississippi River & Bonne Terre railway. The town is at an elevation of about 800 feet above sea level.

The details of the topography are plainly shown on the map of the opposite plate, and the general aspect of the country is well illustrated in the plate opposite page 662. It is seen to be hilly, even rugged in places, and to be traversed by a very meandering drainage system. Immediately about the mines, however, the country is comparatively flat or gently undulating. The extreme range of elevation, within the limits of the small map, is about 400 ft.

HISTORY AND STATISTICS.

The earliest mining at this locality was at what was known as the Pratt mine, and was in progress before the year 1820. Operations were quite limited, however, and were continued in a desultory manner until after the war. The property was early owned by the Aurbuchon family, and was transferred to them by the Valles about the year 1854; it was inherited by Anthony LaGrave through his wife, who was a Valie. In 1866, a large part of the property was sold by him to the St. Joseph Lead company. This company immediately made preparations for more extensive mining; but, during the first few years, many difficulties had to be overcome, and the operations were small and yielded little or no returns [26]. Between 1868 and 1874 work was more vigorous, many improvements were introduced, and the first dividend of 1 per cent was declared in the latter year. The introduction of the diamond drill here in 1869 did much to strengthen confidence and to extend operations. After 1874, the production increased steadily, and the plant was enlarged to correspond. In 1880, a railway to Summit was constructed. In 1883, a disastrous fire destroyed most of the works, but the erection of a new plant was begun at once, and was completed in four months. This admirably designed and well-constructed plant is one of the best of the kind in the country; the mill has a capacity of 900 to 1000 tons of rock in 24 hours. The views opposite page 664 illustrate different portions of it. In 1839, over 300 acres of prospected land, known as the Pen property, were added to the estate, and, in 1886, the Desloge mines adjoining, which had started operations in 1877 and had grown to considerable size, were consolidated with it. Between 1887 and 1890 the Mississippi River & Bonne Terre railway was completed, making an improved connection of the mines with the Missouri Pacific railway, and also with the Mississippi river for transportation. An enlarged smelting plant was also built at Herculaneum, where all the ores are now reduced. The company now controls over 13,000 acres of land, much of which is only partially prospected, and will doubtless prove to contain many tracts of rich mining ground.





From surveys of the Missouri Geological Survey.]

The early production of these mines, before 1864, probably amounted altogether to only a few hundred tons; from 1865 to 1868 the productions averaged 250 tons per year; since that time the outputs have been as follows, as kindly furnished by Mr. C. B. Parsons, superintendent of the company:

<i>Years.</i>	<i>Tons lead.</i>	<i>Years.</i>	<i>Tons lead.</i>
1869	261	1882	7,394
1870	323	1883	5,952
1871	559	1884	6,804
1872	1,060	1885	9,769
1873	1,080	1886	7,872
1874	1,295	1887	7,887
1875	1,963	1888	13,027
1876	2,436	1889	13,600
1877	2,051	1890	13,851
1878	2,819	1891	14,114
1879	3,565	1892	13,474
1880	4,254	1893	14,421
1881	5,317		

In addition to this, the Desloge company produced, from the time of their beginning work up to the consolidation with the St. Joseph Lead company, the following amounts of concentrates, according to Mr. John M. Desloge:

<i>Years.</i>	<i>Tons concentrates.</i>	<i>Years.</i>	<i>Tons concentrates.</i>
1877	928	1882	5,903
1878	1,843	1883	6,770
1879	2,332	1884	7,580
1880	3,531	1885	5,458
1881	4,646	1886	4,542

GENERAL GEOLOGY.

The country rocks about the mines were principally magnesian limestone of the St. Joseph formation. Some argillaceous shale, called slate, is also found; the La Motte sandstone occurs at depths under the limestone, but is nowhere exposed at the surface near the mine. No chert occurs in this limestone, nor is it formed either in drusy or nodular forms on the surface, excepting over the hills southeast of the town.

The entire thickness of the limestone series, within the area of our map, must be in the neighborhood of 600 ft., reckoning from the hill-tops to the bottom of the drill-holes. The upper 100 ft. or so of this contain more or less shale, and the magnesian limestone is, in part, thinly bedded and flaggy; under this are some 200 ft. of thicker bedded, massive limestone, in which the ore occurs; below this again, there is argillaceous shale for about 30 ft., followed by 100 ft. or more of magnesian limestone, which is sandy to a greater or less extent, and containing also some thin layers of shale; this is followed by the basal sandstone of yet undetermined thickness.

The magnesian limestones are generally of a gray color when unweathered, are dense and crystalline, or granular, or pitted with numerous small cavities, such as have been described in the preceding chapter on the lithology of the region; they are sometimes of a bright green color, from contained chlorite, are often arenaceous, passing into sandstone, especially in the lower horizons.

The shale is of a greenish or bluish color, argillaceous, frequently with thin layers of magnesian limestone intercalated; it becomes very friable and soft on exposure to the weather.

The sandstone of the lower members of the limestone series is highly calcareous, is of a gray color, and it is often impossible to say where the dividing line should be drawn between it and the associated magnesian limestone.

Of the basal La Motte sandstone, only one set of specimens was seen by the writer, namely, those from drill-hole No. 50 C, located on the map. These cores were of soft, friable, brown sandstone, the grains being well rounded and not enlarged by crystallization, and held in a matrix consisting of very fine sand with little or no lime.

Drill-hole Records.—A number of drill-hole cores were examined by the writer, and a larger number of records from drillers' notes were studied. Some of the last were recorded, and the following sections are prepared from these. The approximate locations of these drill-holes are shown on the map:

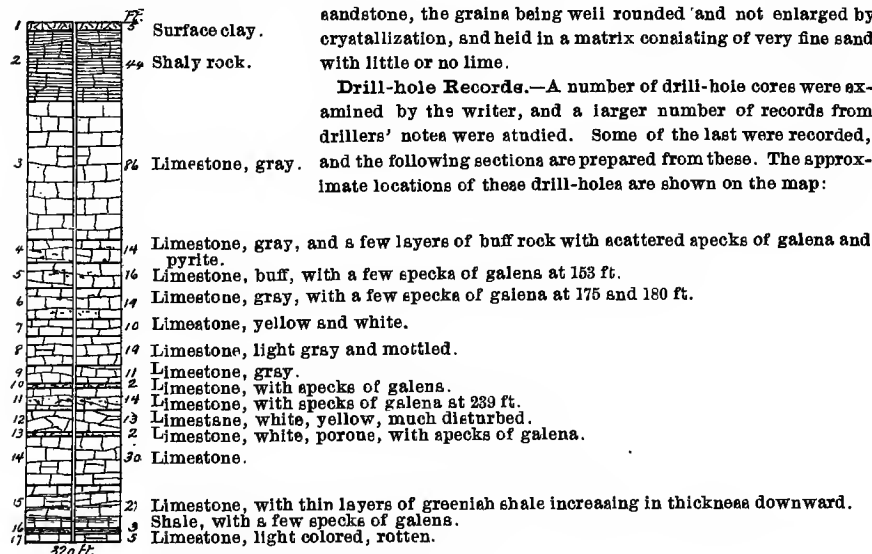


FIG. 211. Record of Drill-hole No. 10, SE. $\frac{1}{4}$ section 15.

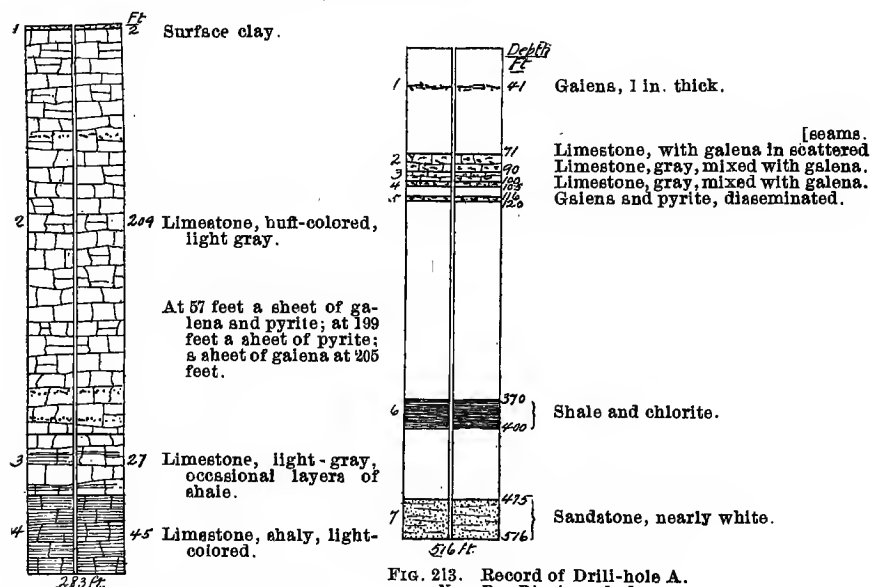


FIG. 212. Record of drill-hole No. 246. Near middle of E. line Sec. 14.

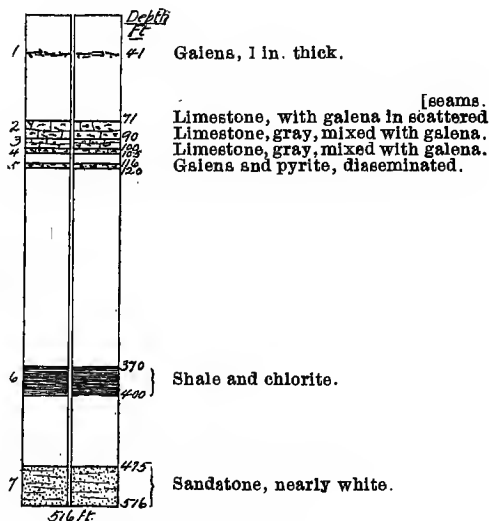
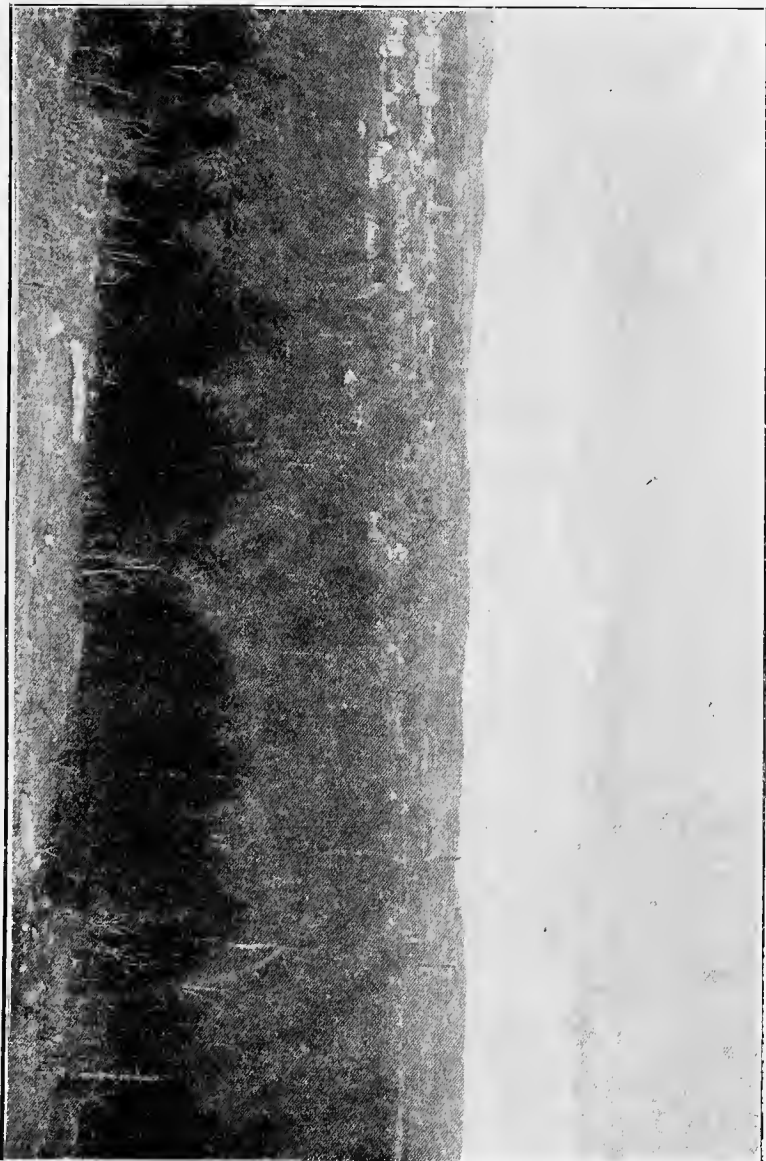


FIG. 213. Record of Drill-hole A. Near Pen Diggings shaft.



VIEW OF THE COUNTRY ABOUT BONNE TERRE.

Other holes, put down near No. 10, show a similar succession of rocks, with varying quantities of galena below depths of 130 feet. The shale near the surface characterized all of the holes, as did also similar rock at depths of 300 feet or more; lead ore seemed most abundant at medium depths.

Numerous holes were sunk immediately about No. 246, to depths reaching 376 feet; they all showed about the same succession of rocks, with varying amounts of galena, pyrite and calcite, below depths of 150 feet; in all the holes a shaly series of beds was encountered near the bottom.

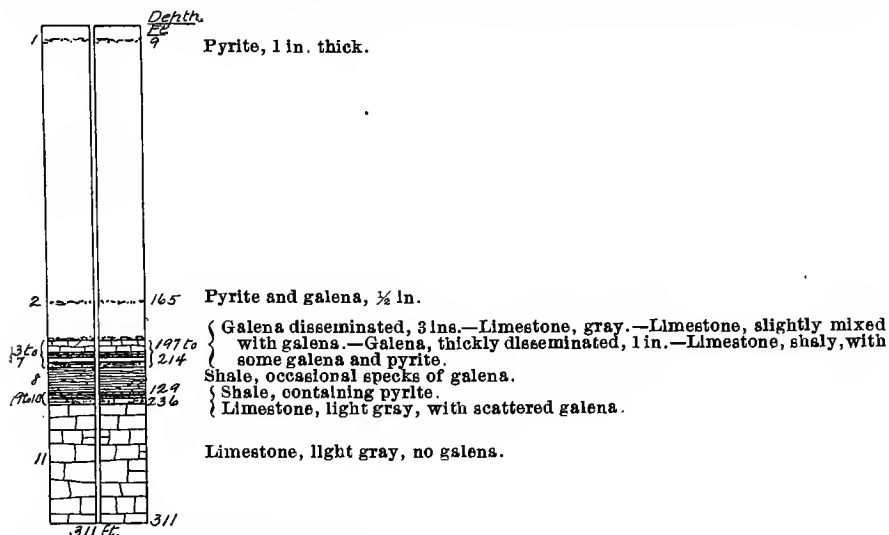


FIG. 214 Record of Drill-hole No. 56 A.
SW. corner Survey 3099.

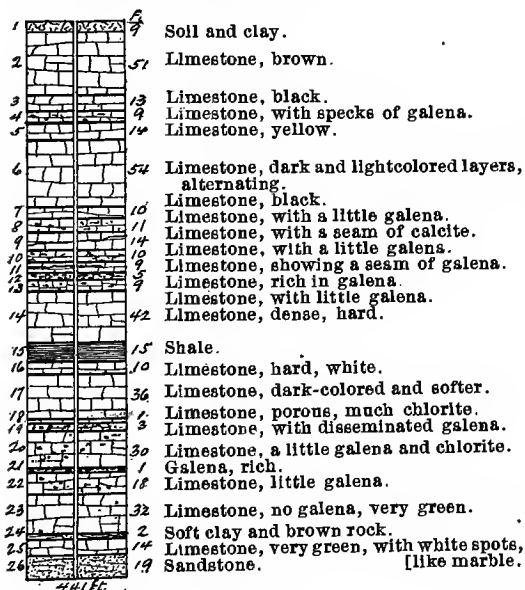


FIG. 215 Record drill-hole No. 46,
NW. of Pen Diggings.

A large number of other holes, put down in the immediate vicinity of No. 56 A, showed similar conditions. The amounts of galena and pyrite varied of course in the different holes; below depths of 200 ft. shale was invariably encountered, and, beneath this, there was, as a rule, little or no galena in the limestone. A summary of these holes would, therefore, be somewhat as follows:

1. From surface to 180 ft.—gray limestone with a little galena in seams, but little or no disseminated ore.
2. From 180 to 240 ft.—gray limestone, with disseminated ore.
3. From 240 to 321 ft.—light gray limestone capped by shale, with little or no ore.

Northeast of these last holes, a large number were put down by the Desloge company in the direction of the Pen diggings property. Figure 215 is a record of the deepest of these:

The depth of the sandstone and the presence of the shale-bed are to be

noted here. Similar results were obtained in other holes, though, of course, varying as to mineral

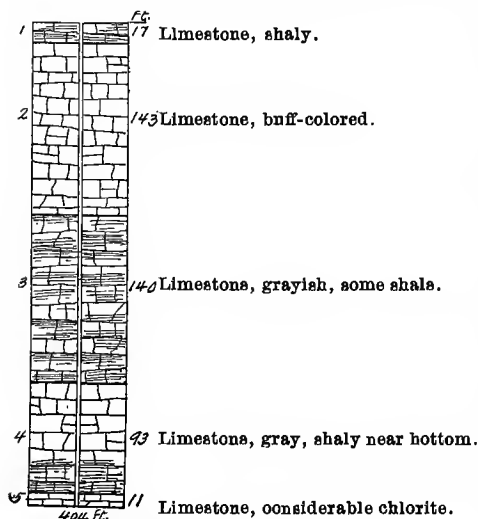


FIG. 216. Record Rohan Drill-hole No. 2.
SE. $\frac{1}{4}$ of SW. $\frac{1}{4}$ of section 10.

through the basal sandstone, a difficult operation on account of the clogging and cutting of the bit by the friable sand. Figure 219 illustrates a record made by the writer from an inspection of the cores from one of these. It was interrupted on account of the loss of part of the drill-rod in the hole.

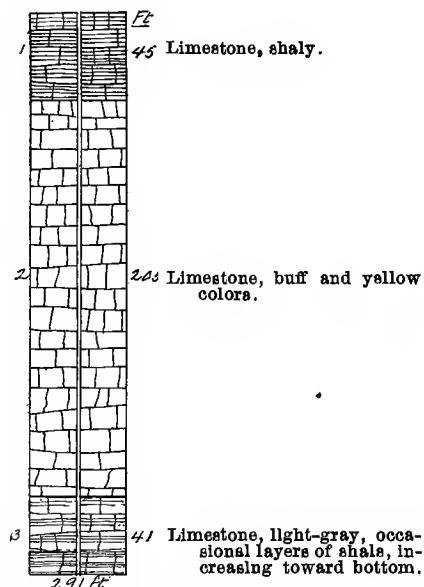


FIG. 217. Record Turley Drill-hole No. 8.
Along W. line section 10.

contents, color of rocks and depths at which shale are encountered. Some galena was found here below the shale, though it was most abundant above that horizon.

Within a distance of a mile or two west of the town, a number of drill-holes have been put down on different properties at points indicated on the map. Figure 216 and succeeding ones show some of the results obtained here.

Numerous other holes were put down immediately about Rohan No. 2 to depths of nearly 400 feet; they all showed similar conditions; were somewhat shaly in the first 20 feet or so, and, again, at depths of between 250 and 300 feet; they were also chloritic near the bottom.

In a number of other holes, put down in close proximity to the Turley and Vandiver holes, the upper and lower shale zones were encountered, showing that they are continuous.

Recent effort has been made by the company to sink one or more drill-holes down

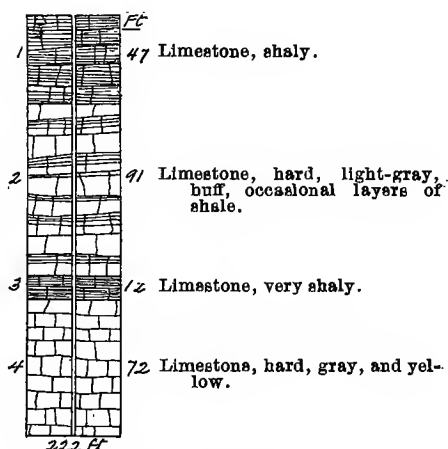


FIG. 218. Record Vandiver Drill-hole No. 14a.
In W. $\frac{1}{2}$ of NW. $\frac{1}{4}$ section 10.

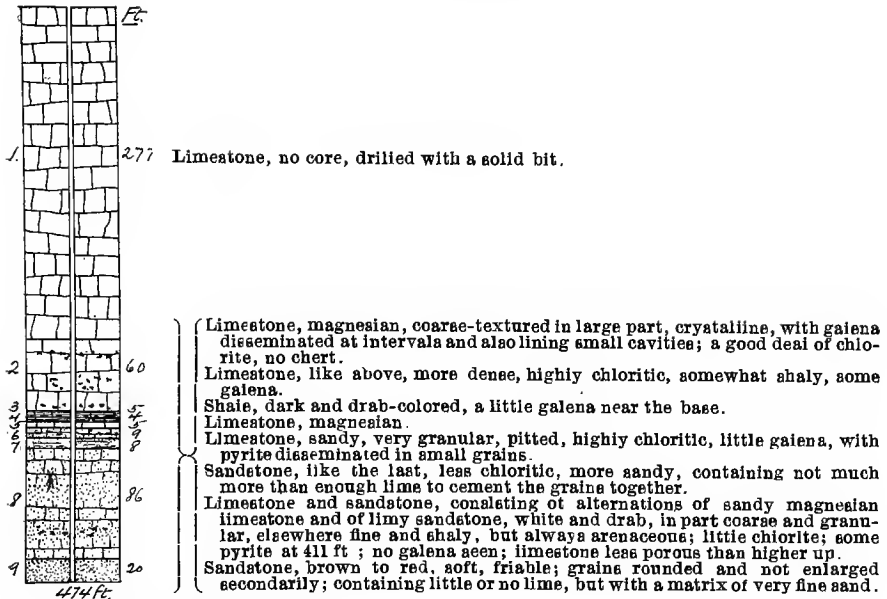


FIG. 219. Record Drill-hole No. 51 C.
S W corner of Survey 3090.

Structure.—The strata of this area are normally horizontal in short exposures, though local dips of 10° , more or less, are observed. In extended exposures, however, along the railway cuts, northward dips of 1° to 2° are traceable, as is illustrated in the cross-section, figure 210. No fossils occur in the rocks whereby different exposures can be correlated, and thus the general dips determined; neither are the lithological differences between the limestone beds sufficient to permit this; the shale beds above referred to are, hence, our best guides for such purposes. Beds of such shale are exposed in a railway cut south of town, as shown on the map, at an altitude of about 900 ft. A. T.; shales also crop out south of the railway bridge over Big river, as is also shown on the map. At the first place, only a few feet are exposed; at the latter they aggregate some 15 ft. in thickness. As we have seen, shale was also struck near the surface, in the Rohan drill-hole No. 2, Turley No. 8 and Vandiver No. 14a. It is probable that the shales of the two railway cuts belong to the same bed; the distance between the two localities is three miles, and a dip of 1° N. would make their connection possible. The view is substantiated by the fact that such shale is encountered near the surface in intermediate drill-holes above the railway depot, in the town of Bonne Terre, as the bed would necessarily pass through the town not far below the surface if such a dip existed. If these two shale beds do belong to the same horizon, the ore-bearing limestone at Big river must be at depths of from 100 to 200 ft. This question cannot be exactly determined without more detailed and prolonged stratigraphic work in this neighborhood than it has so far been practicable for the Survey to do. Its economic importance, as affecting the distribution of the ore, is alone sufficient to recommend such work for the future; had it been conducted, the results would have been embodied in the detailed topographic and geologic maps of this region, for which the field-work is already in large part completed.

THE ORE BODIES.

The ore at the Bonne Terre mines consists of galena disseminated through magnesian limestone, as we have described it at Mine LaMotte. No special kind of limestone seems exclusively favorable for ore, though most of the galena is found in the open and coarse-textured rock, and little or none in the compact and fine-grained varieties; further, much of the rock in the mines is of dark color, probably largely through a decoloration of the calcite and dolomite by iron or manganese salts, though possibly also by organic matter. Neither do we find the impregnations of the

limestone confined to a limited horizon; all portions of the rock above the lower shale beds have yielded ore. The drill-holes cited show a preponderance of galena between the depths of 150 and 250 feet, and most of the mining is now conducted within these limits. In the early days, however, disseminated ore was mined from higher levels, and, east of the Hoadley shaft, disseminated ore in sheets was quarried out at the surface in large quantities.

The galena occurs in the rock generally diffused, or concentrated along stratification planes, in either case intimately mixed with the grains of calcite or dolomite, so as to form an integral part of the rock; it is also found coating and filling minute joint crevices; in general terms, the mode of occurrence is similar to that at Mine LaMotte.

The ore body, at any one point, may occupy one or more beds of limestone of limited thickness; while elsewhere the impregnation may expand, and magnificent faces of ore nearly 100 ft. high have been opened in the workings. This is illustrated in the cross-section of the mine map. No generally established lines or planes limit these ore bodies in any direction, as a rule, but the galena contents usually fade or lean out into the surrounding rock. In some instances, however, stratification planes or crevices mark the limits of the ore. The average contents of the rock as taken out of the mines is about 5 per cent of metallic lead.

Near the surface, concentrated deposits of galena were found in crevices, and, in the days of early mining, these were the principal ores worked. Crevices are also encountered in the deep mines, but they are there not ore-bearing. Mr. Parsons informed the writer that a channel, located about 50 ft. south of the Hoadley shaft, and running thence through the Cottonwood shaft, was plainly displayed in past years of mining, and supplied large amounts of massive galena. This crevice was from 2 to 4 ft. wide; its position is indicated on the accompanying mine map. Several such crevices were developed and worked here, but they were all found to grow narrower and to become unproductive with depth.

The metalliferous mineral of these deposits is now entirely galena, though cerussite was found at the surface in early mining. Absolutely no zinc occurs here, not even enough to be detected by analysis. Pyrite is always present, though it does not necessarily contain copper. Copper pyrite and pyrrhotite, carrying about 4 per cent nickel and cobalt, characterized the upper workings down to a depth of 100 ft. or so. Latterly it has been encountered in the deeper Pen diggings, and the ore, as mined now, according to Mr. Setz, the assistant superintendent, contains from 3 to 4 per cent of copper. From one to two ounces per ton of silver are known to exist in the galena. These impurities class the product as "mineral" lead. Calcite is frequently found in this mine, but no barite was observed. Interesting specimens were obtained here showing pyrite crystallized on galena, and also galena on calcite, which latter fact suggests that the deposition of galena may still be in progress. The galena is crystallized in both octahedral and cubical forms.

On the map inserted opposite this page the extent of the workings of this mine are faithfully represented, the illustration having been made from the company's mine map. The accompanying cross-section is ideal in part. This map shows that the mine extends nearly three-fourths of a mile underground. The drifts, or galleries and rooms, are large, presenting faces about 20 ft. high, and sometimes reaching as much as 100 ft. The shafts are well equipped with cages; the underground haulage is with mules. Compressed air-drills and other improved appliances are used in excavating the ore.

Crevices.—On the map, special pains have been taken to show the distribution and courses of the many crevices which are to be observed in the mines. For this purpose, a tour through all of the workings was made by the writer and the assistant engineer, Mr. Thayer, map in hand, and the positions and courses of all the joints or openings were carefully recorded. The notes of the opposite map give briefly the results. The long crevice running through Cottonwood shaft is referred to above, and is located upon Mr. Parsons' statement. The prevailing course is plainly seen to be between E. to W. and NE. to SW. In many cases the crevices were seen to be non-persistent, and to die out in the roof or wall rock; at other times they were continuous so far as exposed, and may be represented farther on by crevices which are given other numbers on the map. No one series of openings was, however, prominent on account of size or associations, and there is nothing to lead one to conclude that any master crevice traverses the ore body. For this reason, no attempt has been made to represent on the map anything but facts regarding these openings. Anyone who will study this map can formulate about as good an idea as to their possible connection as he could

were be in the mine. No faulting or displacement was noticed along the crevices; they were not open, as a rule, and those that were, generally connected with the surface, and were filled with red mud or clay. Usually they were tight, with lens-like expansions or openings at intervals. Water dripped from most of them, which was highly charged with lime, and coated the surfaces of the rocks and cemented the loose materials which lay on the floor. The relations of these crevices to the formation of the ore deposit have already been considered in a preceding chapter, and need not be further discussed here.

The following brief notes taken by the writer during inspections of the mines are added for purposes of more specific reference:

Shaft No. 1—In the old, upper diggings of shaft No. 1, about 100 ft. beneath the surface, the crevices are particularly abundant, as is shown on the map. At a point in the lower workings, known as the "Incline face," the rock is much shattered, and contains masses of crystallized calcite surrounding blocks of wall rock. The ore body was very rich here, and, though no ore was found in the crevice which traverses the rock, this crevice was followed in the process of mining according to the common practice; strings and sheets of ore were noticed to lead off from the crevice and to terminate with it. In the Pen diggings, the face of ore at time of inspection was 100 ft. high, and was very rich; the galena was observed in crystals associated with calcite, and also lining minute crevices, as if the rock had been thoroughly honeycombed before the ore was deposited.

Shaft No. 5, when visited, was 250 ft. deep. The ore was mined in a drift about 40 ft. high; it occurred disseminated through a dark limestone, and also concentrated along and adjacent to planes of stratification. The rock at the bottom of the drift was a soft magnesian limestone, decomposing to a gritty clay. In sinking the shaft, no run of ore was encountered above the level of this drift.

Shaft No. 4, about one-half mile northeast of No. 5, was 160 ft. deep, and the top of the shaft is probably 30 ft. above that of No. 5; thus the ore, which is mined in a drift at the bottom some 30 ft. high, is over 100 ft. above the level of the run in shaft No. 5. The rock in this shaft is a dark limestone like the last. The galena is generally diffused, but is also concentrated adjacent to the stratification planes. Joint-planes were observed with an approximate E. to W. direction, but no well-defined openings were seen. A rich run of ore was found near the top of the drift, being quite sharply limited by an overlying, somewhat soft and yellowish magnesian limestone.

THE FLAT RIVER MINES.

Flat river is a small tributary of Big river, and empties into the latter about three miles southeast of Bonne Terre. The mines are situated on both sides of the stream, principally about three miles above its mouth. Some are along the valley close to the stream, others on the adjoining hill-sides. The general character of the topography is similar to that of Bonne Terre, as is clearly illustrated on the map opposite this page. The extreme ranges of elevation do not exceed 300 ft.

History and Statistics.—Mining in southern St. Francois county dates over one hundred years back. The Mine a Gerboire, which was worked between 1742 and 1762, was somewhere in this vicinity, and Mine a Lanye, Mine a Manetou and Mine a la Plata, operated toward the end of the last century, were on Big river. The Mine a Joe or Bogy mine, now the Desloge mine, was discovered in 1801, and was worked extensively after this. Between 1820 and 1830, there are records showing that the Flat River mines produced annually some 200 tons of lead. Early surface mining was also prosecuted upon what is now known as the Taylor land; also at the McKee diggings, about two miles east of Flat river postoffice, and again on the south side of Big river, about four miles west of this postoffice. On the land of what is now the Central Lead company, were the old Butcher diggings. Deep mining at this camp is, however, of very recent date. Most of the diamond drilling, which has led to this, was done during the past six years, and there were no deep shafts sunk before 1890.

The amounts of ore produced during the years of early mining in this locality are not known. Estimates have been given in a preceding chapter, and, as there indicated, the total did not exceed a few thousand tons of galena. Since the beginning of deep mining, much larger amounts have been produced, but only partial figures have been obtainable, and these are given in the following mine descriptions:

General Geology.—The country rocks are St. Joseph magnesian limestones, similar to those at Bonne Terre. They are thinly bedded near the surface, and even shaly as exposed in some railway cuts. Lower down, gray and bluish shaly beds were encountered in one shaft, some as much as 40 ft. thick; but other holes did not show such to be present, and they are probably not persistent. The total thickness of these rocks below the railway at Flat River station is over 400 ft., and to the top of the adjoining hill is about 300 ft. more. The La Motte sandstone underlies these beds, and very arenaceous limestone is encountered near the base, cores of which have been examined by the writer. This latter is often called sandstone, and is doubtless sometimes confused with the true basal sandstone. The thickness of this underlying sandstone is not known. No chert is encountered in these rocks or over the surface at this locality; but south of here, toward Simms mountain, we are informed that drusy quartz or chert is found at places at an altitude of about 900 ft. A.T.

Proceeding from Bonne Terre southward to Flat river, the upper portions of the hills are composed of thinly-bedded, flaggy magnesian limestone, while along Big river, massive, thickly bedded strata crop out, dipping apparently a little to the north. At Flat River station, in the railway cut, the thin beds exposed dip 5° or more southward. Regarded in a general way, however, it is probable that the rocks are practically horizontal between the two places, though characterized by local undulations. This is supported by the fact that the basal sandstone is at about equal depths beneath the surface at the two localities, which, as the map shows, are at about the same altitude.

The Ore Deposits.—The ore here, as at Bonne Terre, consists principally of galena, disseminated through magnesian limestone; formerly, also, large amounts of massive galena were mined from crevices by shallow diggings. These crevices were generally vertical, and had E-W. trends. The disseminated ore occurs at greater depths than at Bonne Terre, and is also nearer the sandstone. These and other details of occurrences will appear in the following descriptions of the localities visited by the writer.

THE DESLOGE MINES.

These mines, which are about a mile northwest of Flat river station, are surrounded by a large number of old diggings of the Mine a' Joe. The surface ore was worked along a belt about

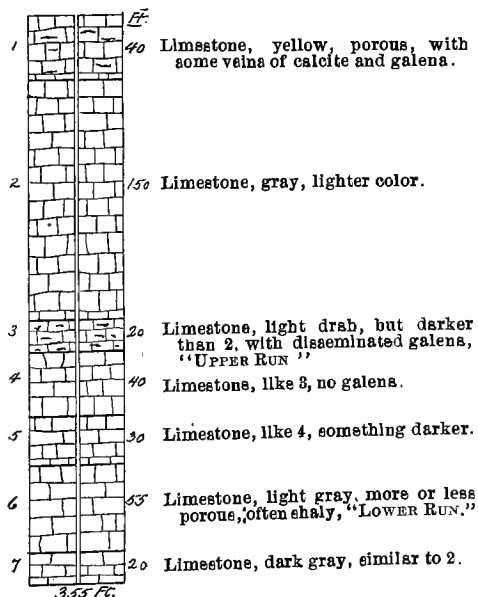


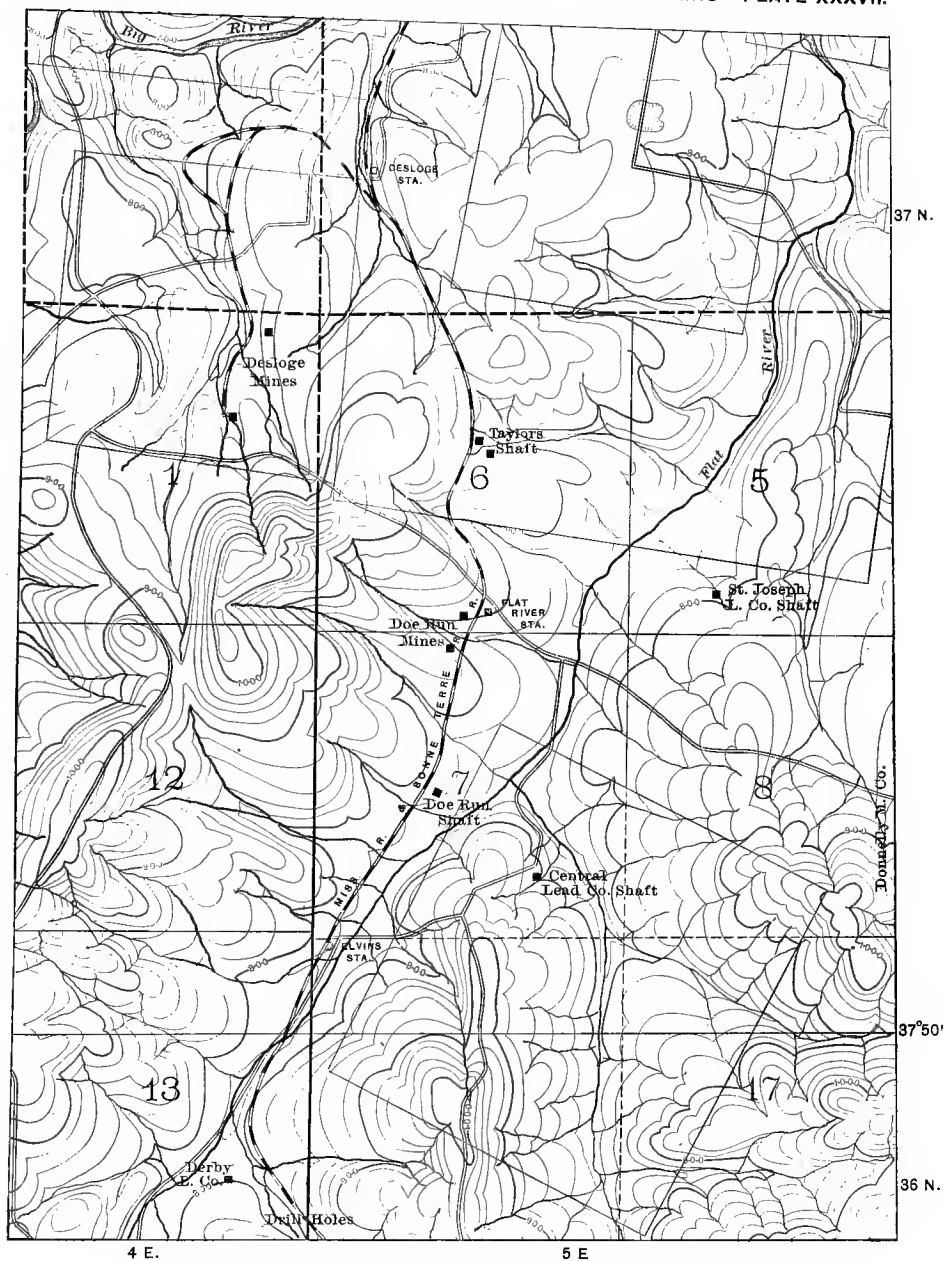
FIG. 220. Record of shaft at Desloge mine.

300 ft. wide, and a mile or more long in an east to west direction. The ore was found in openings parallel to this general course, and Austin describes the galena as occurring in pure masses of several hundred pounds weight.

At the time of inspection, in May, 1892, two shafts were sunk here, 219 and 215 ft. deep respectively. They were connected by a drift running S 22° W. Since then, shafting has been extended. The adjoining figure 220, prepared from notes furnished by Mr. John Desloge, shows the rocks encountered.

Drill-holes below this reached sandstone at 412 ft.

The ore is disseminated galena with some copper pyrite, a good deal of calcite and no barite. A few joint-crevices were observed running east to west, from which water dripped, but no ore was seen in them. One of the shafts followed a crevice from the top downward. Chlorite was found in some of the beds. Drilling showed that though the galena is sometimes close to the basal sandstone it disappears rapidly as the latter is penetrated.



TOPOGRAPHIC AND MINE MAP OF THE FLAT RIVER CAMP.

SCALE, 1 INCH = $\frac{1}{2}$ MILE.*From surveys of the Missouri Geological Survey*

THE DOE RUN CO.'S SHAFT.

This shaft is situated close to the depot. At the time of inspection it was 380 ft. deep. As reported by the superintendent, the rock passed through was principally gray magnesian limestone but beds of shale were encountered ranging up to 30 ft. in thickness. One bed of such shale is said to occur from 30 to 40 ft. above the run of ore. Only one such run was found, and this near the bottom of the shaft. The ore was disseminated through the rock in the usual way. Immediately below the bottom of the shaft, very arenaceous limestone was encountered in drilling, which is, not without reason, called sandstone. Joint-planes were noticed traversing the rock in E. to W. and N. 70° W. directions. Much water was encountered in this mine and caused the abandonment

of one shaft. Many drill-holes have been put down here and over the adjoining tracts of ground by the Doe Run company.

Reference to the productions of this mine will be made later, in connection with the outputs of this mine at Doe Run.

THE TAYLOR MINE.

This shaft is situated about one-half mile north of the last. At the time of inspection it was 225 ft. deep and, was being extended to a depth of 375 ft. The first ore was encountered at about 160 ft. The record of a closely adjoining drill-hole is given in figure 221.

Quite a large number of drill-holes have been put down upon this tract with gratifying results to the company.

THE CENTRAL MINING CO.

At the time of the last inspection, in November, 1893, the shaft was 380 ft. deep. The rocks penetrated are indicated in the following figure 222, from the record of drill-hole No. 2, closely adjoining the shaft.

Ore was mined here from two levels—one at a depth of 240 ft., the other at about 370 ft. In the upper level some iron and copper pyrite, and also, which is specially worthy of note, some zinc blende, were found; but very little pyrite and no blende were seen in the lower level. A yellow sandstone occurs at the base, with sometimes a grit containing porphyry fragments and decomposed feldspar. In the dark, sandy, lower ore body, small and well-rounded pebbles of porphyry were discovered by Mr. Arthur Thatcher, the superintendent, bedded in a limestone matrix. Slides of these pebbles, when examined under the microscope, show that more or less decomposition and alteration has taken place, and that particles of galena have penetrated into the mass and occu-

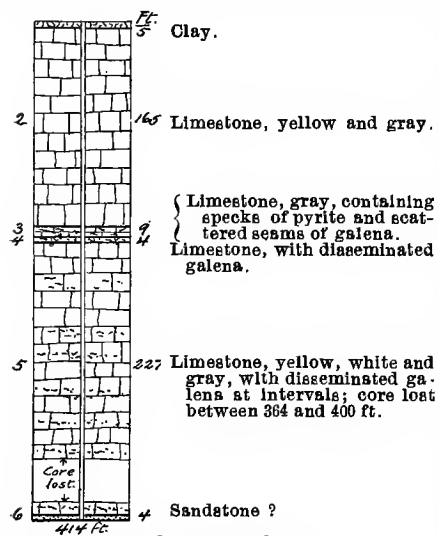


FIG. 221 Record of Taylor shaft.

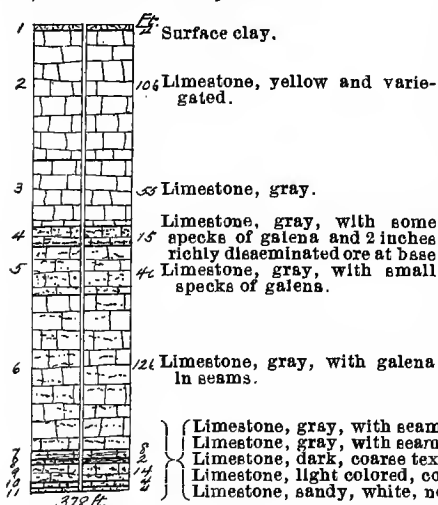


FIG. 222 Record drill-hole No. 2, Central Mining company.

ried the spaces of decomposed feldspar crystals. It is to be noted that beds of shale are not found here, though shale occurs in thin laminae in limestone strata. Some calcite is associated with the

ore, but no barite. According to Mr. Shaw, a former superintendent, a crevice was struck in an old shaft closely adjoining, which extended vertically to a depth of about 60 ft., where it opened out into a large clay pocket with massive galena. Galena was also found all the way down in this crevice. At the bottom of the pocket, the opening contracted to a width of about 1 ft. Its course was E. to W. The following diagram illustrates the character of the ground here as developed by recent drilling. It is a copy of a cross-section prepared by Mr. R. D. O. Johnson, the assistant superintendent:

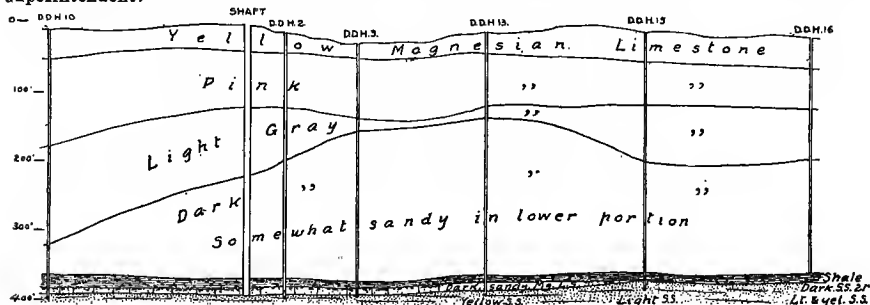


FIG. 223. Cross-section through the Central Mining Co.'s mine.

Shipments from this mine began in July, 1893. During that and the succeeding four months of the year, 100 tons of concentrates were produced, which yielded 67 tons of lead, or 67 per cent.

OTHER DEVELOPMENTS.

During the past few years, a large number of drill-holes have been put down over the surrounding country for a distance of seven miles from Flat river, and shafts are contemplated at several localities. The St. Joseph Lead company have sunk a shaft and erected a plant on the hillside, about one mile east of Flat river station, and some rich cores obtained within the past year from this ground were seen by the writer.

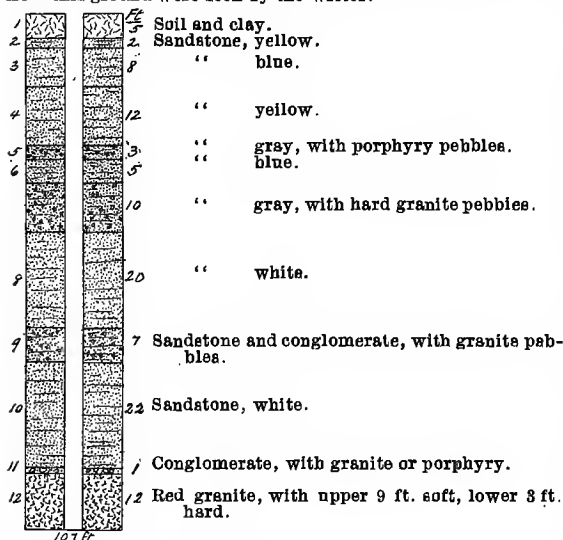


FIG. 224. Drill-hole near foot of Simme mountain.

drill-hole neighborhood has not been the site of early mining. Still farther south, very close to the middle of the NW. $\frac{1}{4}$ of section 36, township 36 N., 4 E., on the western slope of Simme mountain, a shaft has been sunk, of which an interesting record was furnished by Mr. L. Fuller, of St. Louis, and is illustrated in figure 224. This record is specially valuable as illustrating the character of the basal La Motte sandstone in proximity to an outcrop of Archean rocks.

About a mile southeast of this, in the southwestern corner of section 9, the Donnelly Mining company has sunk shafts and a number of drill-holes, finding disseminated ore and reaching the sandstone at about 340 ft. About one mile south of Elvin station, close to the railway, a good deal of deep drilling has also been done, some of the holes extending to depths of over 500 ft. No sandstone was encountered in these, but quite a large body of shale or "elate"; in one such hole as much as 140 ft. was passed through, according to information furnished by Mr. Robert Tetley, of Farmington. Disseminated lead ore was found in considerable quantities in some of these holes—a fact of especial interest, because no surface occurrence of ore is known here, and this immediate

THE LEADINGTON OR THE FARMINGTON PROSPECTING AND MINING COMPANY.

About two miles east of Flat river station, in the SE. $\frac{1}{4}$ of section 9, a shaft belonging to this company was visited. It was, in May, 1892, 256 ft deep, and disseminated ore was found in the limestone from a depth of 175 ft. to the bottom, though most concentrated between 175 and 190 ft. The ore and rocks in which it was found are similar to those elsewhere in the district. A large amount of surface mining had been done here in the past, at what were known as the McKee diggings. Joint-planes were seen running through the rock in the mine NE. to SW., but no clay openings were observed. A number of drill-holes were put down in the immediate vicinity of this shaft, and basal sandstone was encountered at a depth of about 340 ft.

THE DOE RUN MINES.

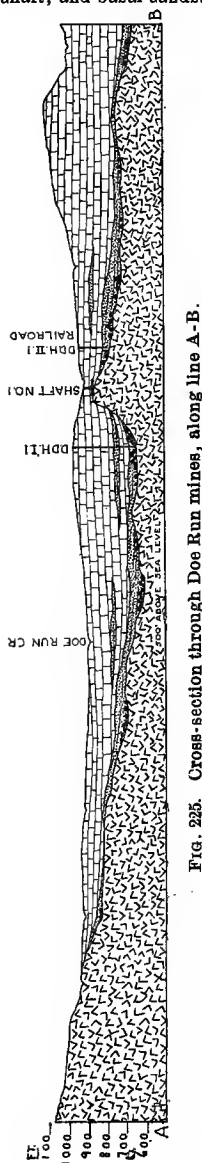
Doe Run is situated about seven miles south of Flat river, on the south side of the St. Francois river, at the terminus of the Mississippi River & Bonne Terre railway, and two miles from DeLassus, on the Belmont branch of the Iron Mountain railway. It lies just north of and between spurs of the St. Francois mountains to the south. The topographic features of the surrounding country are well represented on the opposite map. As is there shown, the mines are, in a general sense, within the St. Francois river valley, and the immediately surrounding country is not so rugged as either to the north or south.

History and Statistics.—The Doe Run mines are an exception to the rule that the deeper bodies of disseminated ore occur and are worked at the levels where surface deposits were mined in earlier years. No lead ore had been found here, and no mining had been done prior to the sinking of a prospect shaft about the year 1885. After this, much drilling was conducted here, as well as over the adjacent country, and the presence of the lead ore was thus well established. With the opening of the mines in recent years an excellent concentrating plant was erected, and steam-power, air-compressors and other fixtures were put in for operating both mines and works. The output since the beginning has been quite large, though not so great as the proprietors had hoped for. The following figures, kindly furnished by Mr. Graves, the assistant superintendent, show the production to date:

1888	3,900 tons of lead
1889	4,080 " "
1890	3,620 " "
1891	3,045 tons roasted ore=2,130 " " (about)
1892	3,300 " " =2,310 " "
1893	3,600 " " =2,520 " "

During the last three years the product of the Flat river shafts of the Doe Run company are included in the figures given; their yields were, however, small until 1893, when, probably, 2,500 of the 3,600 tons of roasted ore came from Flat river.

General Geology.—The country rocks consist of the St. Joseph magnesian limestone, the LaMotte sandstones and conglomerate, and of Archaean granite, probably traversed by dikes of diabase, though the latter are not exposed. The granite is of the common pink color, with a preponderance of feldspar over quartz, and with little or no black mica. The magnesian limestone is of the same character as heretofore described, often arenaceous and chloritic, and sometimes containing numerous fine scales of shale which the lens shows to be fragments of *lingulella* shells. The true shales are gray, drab and argillaceous, though some thinly-bedded, friable limestones are structurally to be classed as shales. The sands are granu-



lar, friable, and of white to yellow colors, sometimes with a calcareous matrix; the grains are small, and show secondary enlargements, and sometimes enclose larger, sub-angular fragments of quartz. The conglomerate consists of granite and diabase boulders and large pebbles enclosed in a limestone matrix, which is rich in chlorite; this conglomerate lies upon the granite floor, or is massed against the granite walls or in depressions of the old surface.

As is shown on the cross-section accompanying the map opposite page 671, the magnesian limestone and other clastics lie upon a very uneven floor of Archean granite, which crops out to the south, and is also encountered in the mine. The surfaces exposed in the mine are well rounded and decomposed, being bleached and partially kaolinized to depths of several inches. The conglomerate is stratigraphically the lowest member, but it is not always present, but occupies depressions and other favorable positions. Sandstone and other arenaceous limestone are the next in ascending order, but these are also principally developed in the basins; thus, on the slopes of the old granite surfaces magnesian limestone is frequently the only rock represented. These conditions are illustrated in the cross-section above referred to, and will be readily understood as a natural result of the deposition of rocks upon a sloping floor. Over the sandstone, a series of magnesian limestone beds appear, which, in the lower part, frequently enclose non-persistent beds of sandstone. Beds of shale are also found within a short distance of the sandstone, but they are not generally represented in the sections at the mine, and are probably not persistent. The accompanying figure 226 of a group of sections about two miles west of the mine shows the variability of these shale beds, as well as their position in the section.

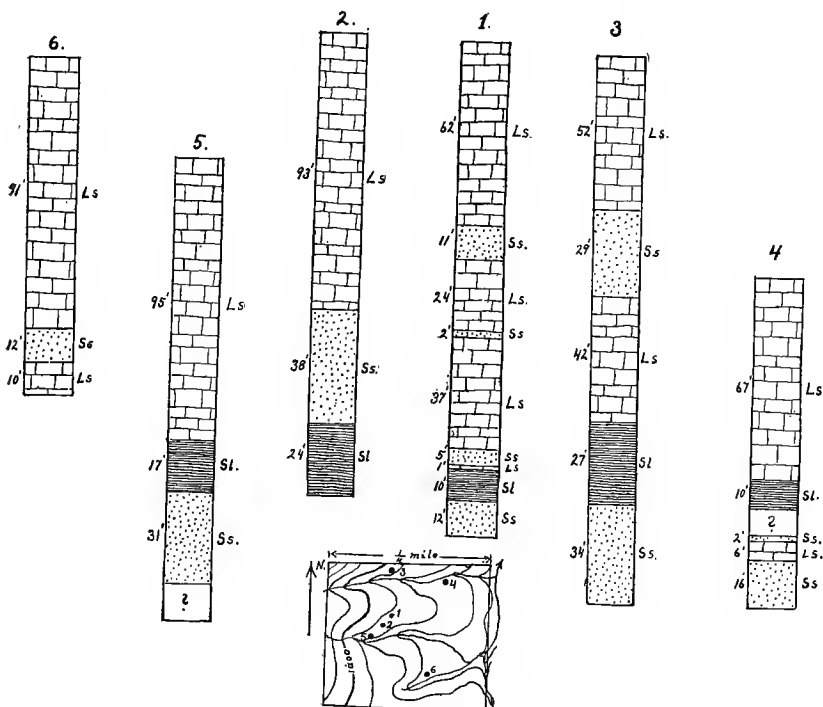
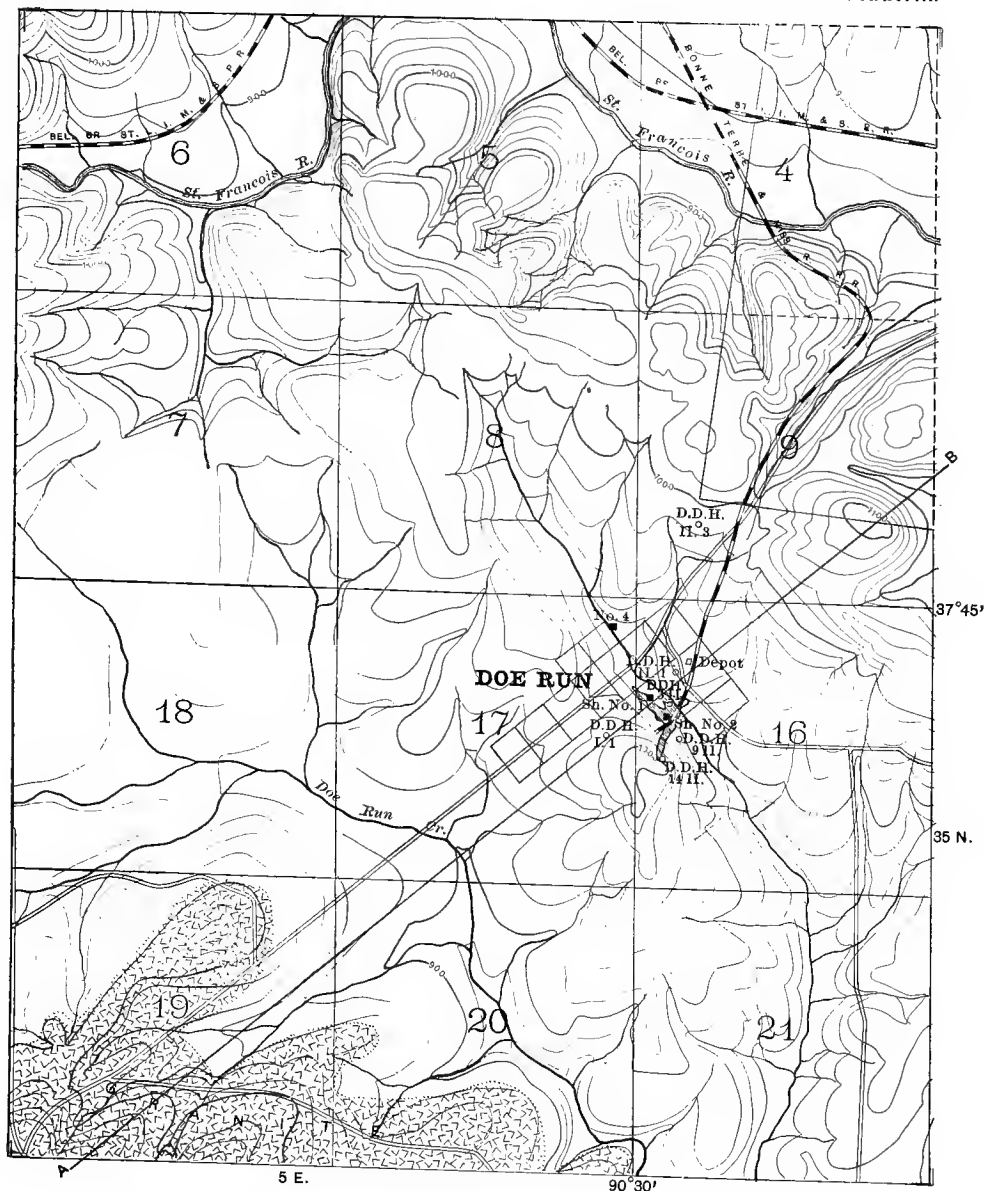


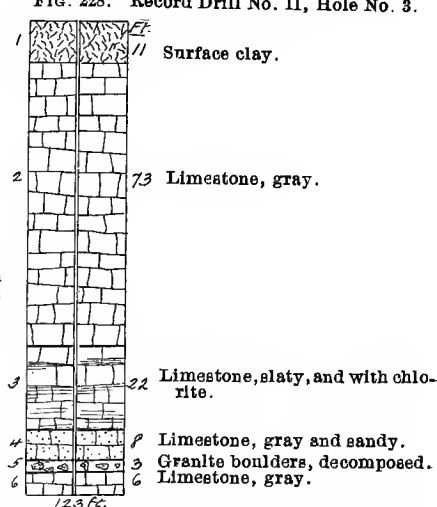
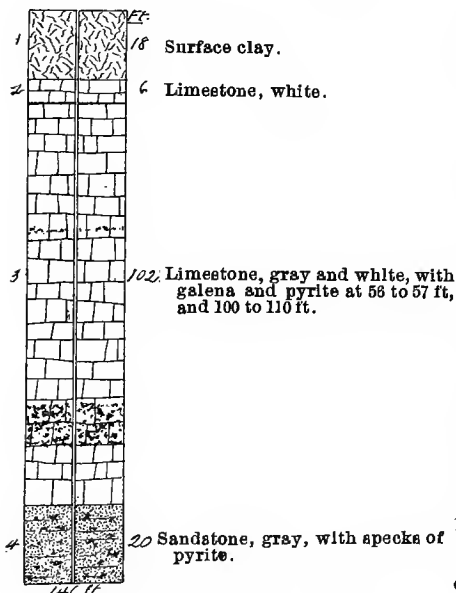
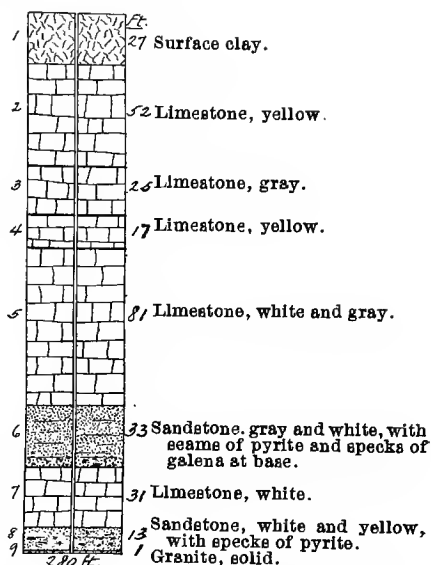
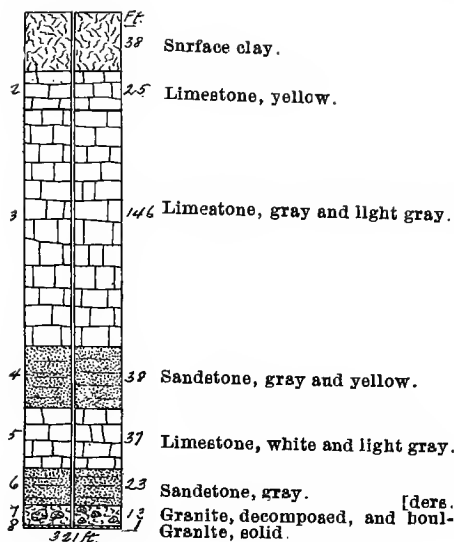
FIG. 226. Group of drill-hole sections near Doe Run, illustrating variability of stratification.

Drill-hole Records.—To further illustrate the character of the rocks encountered here, we add the following record of drill-holes. They are located on the map.



TOPOGRAPHIC AND MINE MAP OF THE DOE RUN MINE AND VICINITY.

SCALE, 1 INCH = $\frac{1}{2}$ MILE.*From surveys of the Missouri Geological Survey.*



Galena was encountered almost continuously in the hole of figure 230; also some pyrite and a little calcite.

The Ore Deposit.—The ore is entirely galena disseminated in limestone, principally between depths of 50 and 90 ft. It is generally in layers parallel to the stratification, but is also along vertical and inclined seams or is uniformly disseminated throughout the rock. The accompanying accessory minerals are principally calcite and pyrite, which latter contains some nickel. Galena is also found in the matrix of the conglomerate between the granite boulders, which are, hence, excavated in mining. Crevices and joint-planes are frequently seen in the mine; many of these

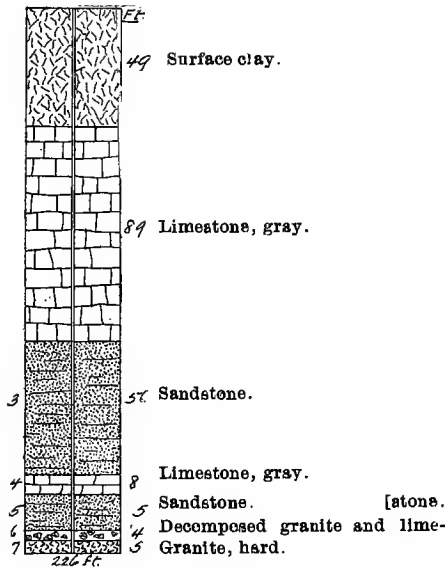


FIG. 231. Record Drill-hole No. 9, Series II.

cease with stratification planes, while others continue across them, and are of undetermined extent. None are of very great magnitude, and they are generally quite tight with no measurable space between the walls, though sometimes they open out to cavities of lenticular sections. The most prevalent direction is WSW., but others are found running nearly N.-S. A number of these are located on the accompanying mine map. Some present clear evidence that there has been no faulting along them, as the stratification is continuous from one side to the other, and horizontal seams of galena run directly across. At other points, the ore is cut off sharply at such places, but generally comes in again farther along horizontally, on the opposite side. Along one prominent and persistent crevice on the eastern side of the mine, indicated on the map, there is much soft material and dolomitic sand, and the surfaces of the rock are slickensided; certain beds of limestone here are more decomposed than others, and are represented by a soft sand carrying galena. Some galena was also found in the crevice itself.

The map of the mine alluded to above is introduced to show the extent of the workings up to the end of 1891; also to indicate the distribution of crevices, the position of granite exposures in the mine, and the depth of the granite beneath the floor at various points. It is not an exact map based upon surveys, as is that of the Bonne Terre mine, but was drawn in large part from memory by the superintendent.

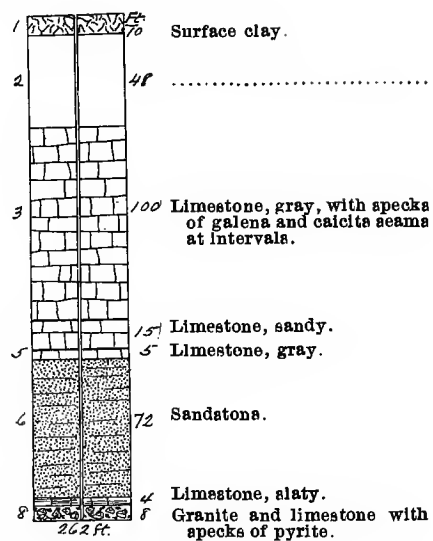
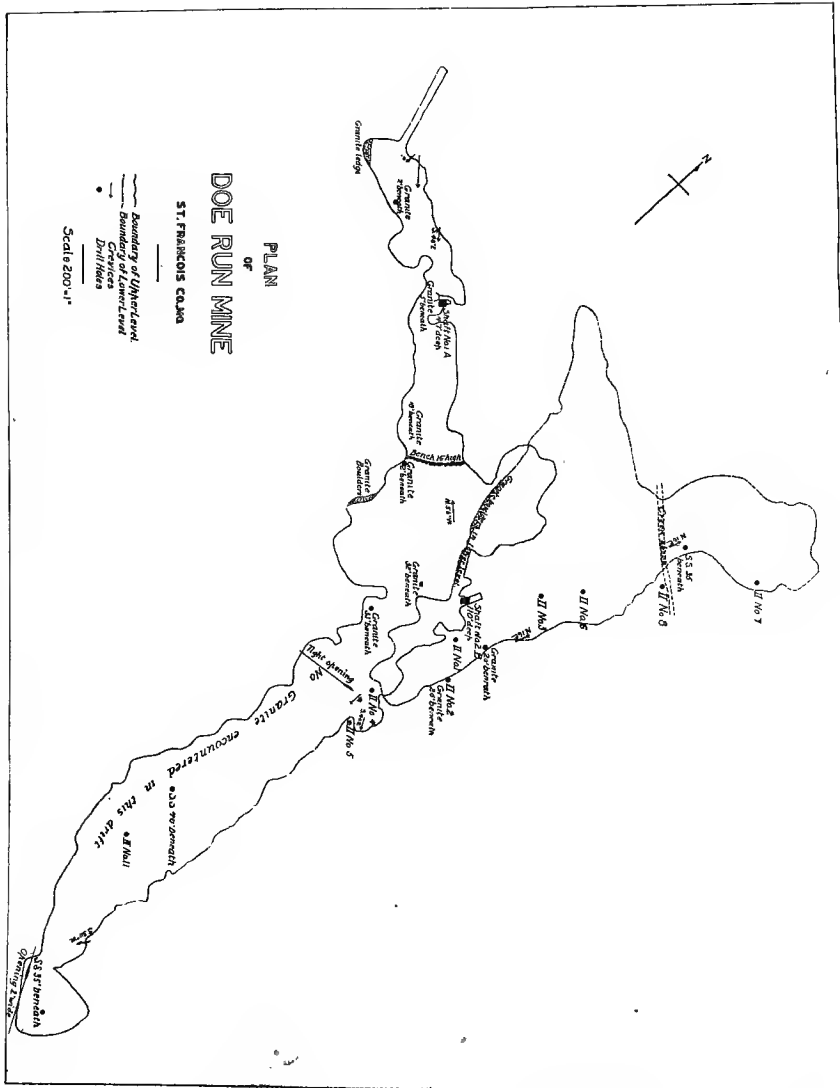


FIG. 232. Record Drill-hole No. 14, Series II.



THE AVON MINES.

This deposit, situated in southwestern Ste. Genevieve county, in the NE. $\frac{1}{4}$ of section 12, township 35 N., 7 E., is of the same character as are those of the other mines of the St. Francois county sub-district, so far described, and is hence introduced here. Work was begun about 1848, and a few tons of ore were produced in that year. Up to 1856, Shumard places the production at 75 tons of ore. Operations were continued until 1859, and other estimates made the production up to that time 750 tons.* Work was resumed in 1872, and continued up to 1874, and not less than 500 tons were raised, according to one report, and according to another, 3 or 4 car-loads of lead.

The Ore Body.—Shumard describes the ore seen in 1856 as consisting of galena, in a thin and nearly horizontal sheet, and disseminated through coarse-grained, dark sandstone; about five feet of such ore-bearing rock was thus exposed, containing also vertical seams of pyrite and bands of other. In 1874, the ore was quarried out from an open cut, and Mr. Gage describes it as galena, disseminated in magnesian limestone, similar to Mine La Motte, the ore-bearing bed being about 2 ft. thick. Dressing works and several furnaces were erected here at that time, and preparations were made for extended work. Since then nothing further has been done; the mines are filled in and opportunities for examinations are poor. Outcrops of rock, containing disseminated ore, have been seen in the adjoining creek beds.

* This and other facts relating to the history and production of the mine were kindly contributed by Mr. John L. Bogy, of Ste. Genevieve, who obtained the information from Judge G. W. Griffith and Judge J. E. Boyd, of Avon.

OUTLYING MINES.

Beyond this group of mines in disseminated ores, within the limits of the sub-district, there are a number of other deposits of a somewhat different type which have been worked in the past.

The Hazel Run or Bryan mines, north of Big river, in the SW. $\frac{1}{4}$ of section 33, township 37 N., 5 E., were worked at a very early date, as has already been stated. Schoolcraft in 1819 described the ore as galena, often in sonorous slabs with a little calcite, and accompanied by no barite, pyrite or blende. As reported by Litton, the ore occurred in crevices or fissures, 6 ins. to 2 ft. wide, running in an E.-W. direction, filled largely with clay containing sheets of galena not over 2½ ins. thick.

Between this point and French Village, some five miles farther east, are a number of old shallow diggings, but descriptions of these have not been obtained. Deep drilling was also done in sections 25 and 35 of the same township; the holes reached depths of about 260 ft., and were entirely in limestone and revealed no lead ore, according to Mr. Robert Tetley of Farmington.

At Mine a Maneteo, on Big river, above referred to, Austin, in 1804, stated that the mineral was found within 2 or 3 ft. of the surface, in small particles in soft, gray limestone. This rock occurred in thin horizontal beds, 5 to 6 ins. thick, separated by spaces of 1 to 2 ins. filled with clay or galena. At Mine a la Plate, he describes the galena as assuming the form of veins in the rock, accompanied by barite.

THE WASHINGTON-JEFFERSON COUNTY SUB-DISTRICT.

This sub-district includes the lead mines of Washington, Jefferson and Crawford counties, and also those in the extreme northern portion of St. Francois county. Within its bounds are, therefore, the mines about Potosi, the Valle mines, and many others that have been so frequently referred to in preceding chapters. These deposits are distinct in many respects from those of disseminated ore in the St. Francois sub-district, and are all substantially of the same type, occurring principally in horizontal sheets or net-works, associated with clay and barite, and not so often in vertical crevices. Considerable zinc ore is found in some deposits, sometimes blende, but principally the oxidized "silicates." The quantity of barite associated with the galena makes it often an object of independent search. These are the principal reasons for making one sub-district of so large and irregular an area.

Though the mines of this sub-district have produced nearly one-third of the total yield of southeastern Missouri, its rate of production has never been so great as is the present production of the smaller St. Francois district; the rate has, however, been uniformly large for the past hundred years, and is maintained up to the present time.

The rocks in which the deposits occur are the Potosi magnesian limestones of Lower Silurian age; these limestones differ from those described at the St. Francois county mines, in that they generally contain chert in nodules and layers, and also drusy quartz in irregular masses, such as have already been described. Associated with the strata of limestone are also strata of sandstone and chert. The position of the rocks is normally horizontal, though strong dips indicative of local disturbances are observed over limited areas. The stratigraphy is such as requires the most detailed study in order to fully display the structure and formations.

The density of mining over this area has been very great, though most of the openings were shallow and confined to the surface clays. Litton, in 1854, characterized all of Washington county as one extensive lead digging, with scarcely a section upon which no ore had been found, and scarcely a township without a mine.

The principal groups of mines or camps are about Potosi, Richwoods, Fouche a Renault, Kingston, Old Mines, near Irondale and Caledonia, along Big river and about Palmer, all in Washington county; the Mineral Hill or Williams mines in Crawford county, the Valle mines in Jefferson and St. Francois counties, and the Frumet, Mammoth and Platin creek mines in Jefferson county. Many of these have not been worked for a very long time, no descriptions are preserved, and everything is fallen shut, so that nothing of the mode of occurrence of the ore can be seen. Others have received notice in previously published reports, and, with the light of present knowledge, much of additional value is to be gathered from such old descriptions. A few of the mines have been operated during recent years and were examined. The following descriptions embody, therefore, first, the results of these recent examinations, and second, as supplementary, extracts from the information contained in earlier reports.

Concerning the productions of these mines of this sub-district, little detail can be added beyond what is given in the statistical chapter. The mines have been so numerous, and many of them so small, that individual outputs have not been recorded or preserved. Statisticians have generally gone no farther than to give the yield of whole camps, or of furnaces which derive their supply from many different mines.

WASHINGTON COUNTY.

THE POTOSI MINES.

The Potosi mines, or Mine a Burton, discovered in 1763, have been the scene of almost constant mining ever since. The openings or diggings about this place which have been worked are practically numberless, and it is out of the question to describe or even enumerate any large proportion of them. They were mostly shallow pits in the clay, however, and the conditions of occurrence of the ore must have been similar in all. During late years, more mining has been done in the magnesian limestone country rock, and a number of shafts 100 ft. and more deep have been sunk. Very little work has been in progress about Potosi during several years, and opportunities were afforded for only a few underground observations.

The Bugg shaft.—This shaft was visited by the writer in the summer of 1892, and at that time was 112 ft. deep. It is located a mile SSW from the town. The country rock is a white or drab, siliceous-looking magnesian limestone, containing very small drusy cavities lined with dolomite crystals; it is of this character from top to bottom of the shaft.

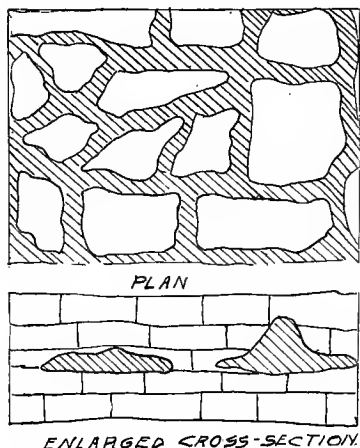


FIG. 234. Ideal plan and cross-section of ore channels in the Bugg shaft.

The ore occurs in "runs" or channels near the bottom of the shaft, which follow the stratification, and, crossing and uniting, form a network of runs surrounding pillars of barren limestone, somewhat as is shown in the adjoining figure. The height of these ore channels is generally only a few feet, but sometimes they enlarge to cavernous dimensions, as much as 20 ft. high; elsewhere the height may be only 20 inches. In width they vary from 3 to 10 ft. At the mine, the metalliferous mineral is exclusively galena; the gangue is principally barite and some calcite; in the larger openings some red clay is found. One vertical crevice traverses these workings, running N. 70° W. (mag.), and extending to the surface. In width it varies from 0 to 10 feet. It stands nearly vertical, and is traceable at the surface for over a quarter of a mile. Both galena and barite were found in this crevice. Runs of ore at two upper levels have been worked in this mine, and the ore was found to "pitch" from one to the other.

No zinc ore occurs in this or other adjacent openings, though it is found in other mines on the north and west sides of the town.

The McArthur mines (R.).—Under this title are included a number of mines upon some 10,000 acres of land, including several old Spanish and French grants. Mining was begun here in 1798 by Moses Austin on the well-known Mine a Burton tract, and since then has been carried on with greater or less diligence to the present day. The Castleman, Citadel and other old historic shafts are included in this property. One of the openings is described as follows by Mr. Robertson:

The Curtis and Hall shaft was formerly the old Willeke property. It is very near Potosi. The shaft was 32 ft. deep, in a close-grained, earthy, dove-colored limestone, containing cavities with small quartz crystals. The ore (galena) occurs in a succession of pockets in a stratum of limestone,

at a depth of 30 to 32 ft.; the mineralized portions or channels are from 2 to 8 ft. in width and about a foot thick, sometimes increasing to 6 ft. This portion contains pockets filled with barite enclosing the lead ore, although the lead may occur in the limestone direct, with no barite gangue, but in this case in much smaller bodies. The usual occurrence is a body of barite lying horizontally about 4 feet wide and 6 inches to 1 foot in thickness, heavily mineralized with galena, which occurs both as more or less perfect crystals and as irregularly shaped masses. This ore body has generally a course about N. 20° W., but branches off in directions S. 60° E. and S. 60° W. It is significant that these are the general directions of the jointage planes of the limestone. The galena is found in masses weighing from a few ounces to several hundred pounds. The barite occurs as the white opaque variety, often in masses stained yellow and black on the surface by iron and manganese, and covered with small tabular crystals. Calcite is often associated with the barite, crystallizing on it in compound scalenohedra.

In a shaft which was being sunk about one mile from the latter property, a distinct crevice was observed. The strike was nearly N.-S., and the crevice was about vertical. It was 2 to 6 inches wide, filled with barite and galena, lying in irregular masses in the barite. The wall rock was heavily bedded, siliceous magnesian limestone, and was apparently absolutely unaltered. No movement in the wall was perceptible. The crevice had been followed for about 60 feet in depth.

Austin, in writing of Mine a Burton in 1804, described the ore as found within 2 ft. of the surface. He separated it into two kinds: 1) "gravel mineral," found immediately under the soil, mixed with gravel and coated with cerussite, and extending into sand rock below; 2) mineral in a bed of red clay under the sand rock, in pieces from 10 to 500 lbs. in weight, associated with barite.

Schoolcraft, in 1819, described the ore as found in detached pieces and solid masses, in veins and beds, in red clay, accompanied by barite, calcite, pyrite and quartz. In the clay near the surface "radiated" quartz was found. The gravel ore occurred under 4 or 5 ft. of red clay, and consisted of fragments or "pebbles" of siliceous rock mixed with galena, the whole about a foot thick. At the New Diggings he reported that the "most flattering veins" were in view when water caused their abandonment. In the Austin shaft he speaks of large quantities of ore filling crevices in the rock.

Broadhead, describing this lead district in 1876 [31, p. 105], refers to the occurrence of galena in red clay at Mineral Point, and also of barite and galena in horizontal bands in limestone. He also mentions the finding of specimens of barite which had replaced galena, as is proven by the presence of right-angular galeniferous lines.

OLD MINES AND VICINITY.

About 5 miles north of Potosi is Old Mines postoffice, about which mining has been prosecuted since 1725. As at other points, most of the diggings have been in the clay or shallow shafts. Very few developments have been made recently, and few opportunities for observation are now afforded. The following descriptions are hence based principally upon Litton's report of 1854.

At the Old mines, themselves most of the galena was found in the surface clay and debris. Where found in the rock, it occurred in openings or caves, associated with barite. Shafts had been sunk in 1854 to depths of 54 ft.

At the Prairie diggings, on the Old mines tract, Broadhead described a "run" 7 ft. wide and 55 ft. deep, extending nearly due N. and explored several hundred feet. Other short runs or cave openings meet the main one, but generally terminate within a few feet. The openings were filled with masses of decomposed magnesian limestone country rock, barite, pyrite, galena and calcite, sometimes in irregular and confined aggregations, but often in broken horizontal layers.

At the Scott and Bee diggings, in the western part of section 22, township 38 N., 2 E., depths of 65 ft. had been reached. The galena was found in connecting caves or openings in a light-gray, sub-crystalline magnesian limestone. These openings occurred in three series at depths of 20, 30 and 40 ft. respectively, and were nearly horizontal. Their courses are N.-S. and E.-W. They were filled with clay, galena and barite, and sometimes partly with limestone. In places, isolated chimneys of ore, extending to depths of 40 ft., were encountered.

The Shibboleth mines, discovered about 1811, are some three miles east of Old mines, in section 21. They yielded large amounts of ore during the first years of operation. The principal mining was over an oblong tract about a mile long in an E.-W. direction, and a quarter of a mile broad. Almost all of the galena was obtained from the surface clay by shallow pits 16 to 40 ft. deep. The deepest shaft was 50 feet. Some deep drilling has been done here during recent years.

About Belfontaine, two miles north of Shibboleth, a number of mines have been operated. The deepest shaft was down 75 ft., almost entirely in clay. Barite is associated with the galena. At the Cannon mine, shafts reached depths of 50 ft.; the galena was obtained from the clay, and was associated with some pyrites. At the Prairie diggings, about a mile north of the postoffice, in section 4, a number of shafts were sunk, reaching depths of 40 ft. Galena was found at two levels.

Kingston, in the northeastern quarter of the county, on the Mineral fork of Big river, is the center of a number of small mines. The Wit & Elliot diggings, about two miles west of the town, in the NE. $\frac{1}{4}$ of section 26, consisted of shafts from 20 to 60 ft. deep, in which the ore was found at different levels in the rock. On the Bequette tract, about a mile south of the postoffice, a vertical lode was traced 330 ft. in a N. 82° W. direction, varying in thickness from 3 to 9 inches. Much barite is associated with the galena here, and has been mined and shipped in large quantities.

RICHWOODS AND VICINITY.

About Richwoods, in the northeastern corner of the county, lead ore has been mined during the past 80 years; but, of late, little work has been done.

At the old LaBeaume diggings, in section 32, township 40 N., 2 E., ore was obtained in large part from the surface clay, but also from the rock, in which it occurred at different levels, in horizontal sheets associated with barite.

The French diggings are about three miles northeast of Richwoods, in sections 21 and 28. The ore was obtained principally from the surface clays.

At the Old Dutch, or East Wood diggings, ore is reported to occur in a vertical crevice $\frac{1}{4}$ to 6 inches wide.

FOURCHE A RENAULT AND VICINITY.

Fourche a Renault postoffice is about eight miles northwest of Potosi, in section 7, township 38 N., 2 E. This is near the site of the old Mine Renault, discovered about 1725. As developed in 1804, Austin describes the ore as of good quality, generally found in the limestone in irregular veins. Schoolcraft noted that zinc ore was abundant there as blende, of a black color.

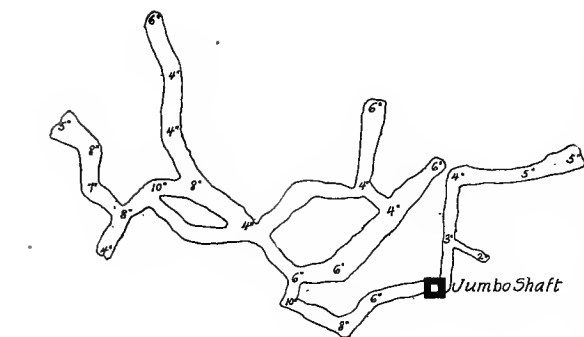
At the Shore diggings, about a mile south, in section 18, a shaft was sunk to a depth of 100 ft., in solid magnesian limestone. At this depth a series of openings was encountered, filled with loose fragments of country rock and clay, galena and barite. Later, the shaft was extended to a depth of 40 ft. farther without encountering any opening.

The Lupton diggings are in the next section to the east (17). They were distributed over a tract half a mile long and about 450 ft. wide. The deepest shaft was 80 ft., and the surface clay was 25 ft. to 30 ft. thick. The galena was found generally in caves in the rock, which connected with each other and were mostly at the same level; a little barite was found.

The Lynch mines, in section 16 of the same township, operated similar cave-filling deposits. Many shafts had been sunk, on an average about 64 ft. deep. From these, drifts were extended for distances of 200 and 300 ft. The adjoining *Casey and Clancy diggings* were distributed along three belts, having a NW.-SE. course. The ore was found in the surface clay and in caves in the rock.

The Cook diggings, in section 8, a little east of the postoffice, were in surface clay.

The Brock diggings are about five miles west of Fourche a Renault postoffice, in section 4, township 38 N., 1 E.; the mining was entirely in clay.



PLAN OF PALMER LEAD MINES

CONSTRUCTED FROM SURVEYS

SCALE 60'=1"

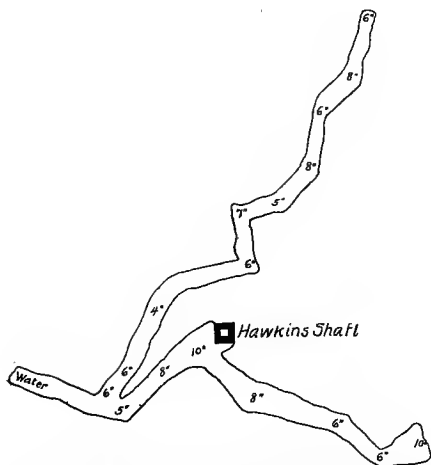


FIG. 235. Map of the workings in 1892 of two shafts of the Palmer Lead mines
Width of channel is to scale; figures are of thicknesses of ore body at respective points.

IRONDALE AND CALEDONIA.

West of Irondale and north of Caledonia are numerous diggings which have yielded considerable quantities of lead and zinc ores, the latter principally smithsonite. The Deggendorf zinc works, two miles north of Irondale, were erected about 1870 to treat these ores. Of late years little or no work has been done at these mines, and opportunities for examination are poor. Much of the ore was undoubtedly obtained from the surface clay, as elsewhere.

At the Faguaher diggings, in section 13, township 36N., 2E., ore was mined in part from openings in the rock, according to Litton, and doubtless occurred under similar conditions in adjoining openings.

The Peach Orchard diggings, described on p. 455 as yielding ore with a somewhat remarkable silver contents, is in this vicinity.

THE PALMER MINES.

The Palmer lead mines are the same as the old Fourche a Courtois mines discovered in 1814. They are located in the southwestern portion of Washington county, principally in and about the northeastern quarter of township 36 N., 1 W. The approximate distribution of important openings is shown on the accompanying map of the southeastern dis-

trict. These mines have been extensively worked during different periods. In 1831, some 200 people were employed here. In 1854, Dr. Litton enumerates over 20 noteworthy openings. Up to that time nearly 4000 tons of lead ore had been produced. The deepest shaft was not over 85 ft., penetrating magnesian limestone. The ore was usually found in surface clay, but also in openings and caves in the rock, associated with barite. Between the years 1870 and 1891, about 10,000 tons of lead ore were produced.

These mines were visited by the writer in the summer of 1892, and also by Mr. Robertson in 1891. The following descriptions are the results of the observations of both, and, though opportunity was not afforded for the inspection of many openings, the deposits described will serve well as types for all of this vicinity.

The Parole mine.—This mine, operated by the Palmer Lead company, is situated in the SE. $\frac{1}{4}$ of section 6, township 36 N., 1 E., near the center of the southern line. The shafts are located on the hill-tops, about 200 ft. above the adjacent valley, and 300 ft. above Palmer postoffice. They vary in depth from 130 to 145 ft. The rock passed through is principally magnesian limestone.

The Jumbo shaft, examined by the writer, was 146 ft. deep. Only one run of ore was found, this at the bottom of the shaft, in a flat sheet generally about one foot thick, but varying from a few inches to 6 ft. This run is made up of a net-work of channels, as is illustrated in the plan of the mine shown in figure 235. Main channels and cross-channels are recognized. The former run generally NE.-SW., and average about 4 ft. in width, though they range from 2 to 12 ft.; the latter average about 2 ft. in width, and run in various directions. The contents of these channels consist generally of galena near the top and bottom, with a filling of barite between. This is exactly illustrated in the accompanying figure 236, from a sketch made in the mine. Near the outcrop, the barite is not so abundant, and pyrite and limonite are found in its place. The barite is clearly seen to be deposited after the galena crystals were formed; it occurs both in nodular, dense forms, and friable, in which conditions respectively it is known as "ball tuff" and "chalk tuff." Well-formed crystals of galena are often found lining small cavities, and crystals of anglesite are sometimes found in these. The country rock is a siliceous-looking magnesian limestone, containing many small druse cavities, lined with dolomitic crystals. Larger cavities are also found, and the rock is thus very open and vesicular in places. These cavities are sometimes filled with clay, sometimes with barite, and are sometimes lined with drusy quartz, known as "mineral blossom" and as "moory flint." Such quartz is very abundant in the residuary clays along the foot-hills, but is not so common on the hill-tops. Patches and lenses of chert are frequently found in the limestone here. Under the main run of ore is generally a series of layers of friable sandstone, and of white and yellow clay; the limestone is usually soft and crumbly, both above and below the bed of ore.



FIG. 236. Ore channel at the Palmer Lead mine.

A number of other shafts were sunk in this immediate neighborhood, all operating the same sheet of ore. Other sheets and runs are found at different levels in other shafts. An upper one, at a depth of about 100 ft., consists mainly of barite, with a little galena and considerable pyrite; it is rarely worked. The second, which is of less importance than the first, is generally about 4 ft. above the lowermost and sometimes runs into it. The third, or bottom, which we have described, is the one principally worked.

In former years, much ore was obtained from the clay diggings, and both galena and cerussite were found. In this clay the galena frequently lay in sheets, which were, however, not horizontal, but lay in "pitches and flats," somewhat as we might expect the contents of such channels as we have described to lie, if the enclosing magnesian limestone were gradually removed by solution.

MINES NORTHEAST OF PALMER.

In section 31, township 37 N., 1 W., are a number of mines, as indicated on the map. These have been worked at intervals during the past 30 years. A few of the openings are a little farther west, in Crawford county, but will be considered here because belonging essentially to the same group. The locality was visited on different occasions both by Mr. Robertson and the writer, and the observations then made are supplemented by notes kindly furnished by Dr. W. A. Metcalf, of Steelville.

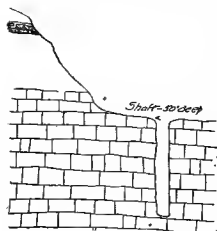


FIG. 237. The Jumbo shaft.

The Jumbo shaft.—This shaft is situated in the NW. $\frac{1}{4}$ of section 1, township 36 N., 2 W., well up in the hills, nearly 200 ft. above the valley. It was sunk by the Star mining company upon a well defined crevice running N. 80° W. The country rock is principally magnesian limestone. These facts and the location of the shaft are illustrated in the adjoining figure 237. The crevice varies in width from one to seven inches, according to our notes, though Dr. Metcalf reports an average width of as much as 2 ft. It dips from 70 to 80° N., and has been traced a distance of over a mile. The contents of the lode consists of barite, calcite, pyrite, fragments of limestone and of limonite, containing galena and blende, the whole intimately mixed in such a way as to be difficult to concentrate. Some 12 or 15 tons of ore were raised, but still remain on the dump.

The Dry Bone shaft is about half a mile east of the Jumbo, in the NE. $\frac{1}{4}$ of the same section. The shaft had been sunk about 40 ft.; massive dry bone or cerussite was found near the surface. The same vein as in the Jumbo shaft was encountered here, containing similar ore, but without barite.

The Kellogg shaft is about a quarter of a mile east of the Dry Bone shaft, in the NW. $\frac{1}{4}$ of the adjoining section 6. The shaft, 36 ft. deep, was sunk on the same lode, containing ore similar to that of the Jumbo shaft, with considerable barite. It is entirely in magnesian limestone, with the exception of about 2 ft. of decomposed chert near the top. The average thickness of the lode is from 6 to 8 in., and it dips about 80° N. It sometimes reaches 3 ft. in thickness. Galena is the principal ore, but much massive cerussite was found in the surface clay.

The Little Saturday shaft, of the Martin Mining company, is about one mile northeast of the Kellogg, in the SE. $\frac{1}{4}$ of section 31. The shaft was 34 ft. deep, and entered a large clay opening near the base. The adjoining figure 238 is an ideal cross-section through this shaft.

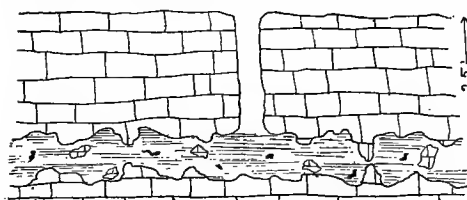


FIG. 238 The Little Saturday shaft.

The opening is horizontal in position; is between limestone beds, and is completely filled with clay of red color, very plastic and homogeneous, but showing distinct, horizontal bedding-planes. In this clay are frequent blocks of limestone, and also large slabs of galena, often in the form of an aggregate of big cubic crystals, with surfaces

somewhat rounded and coated with cerussite. The surfaces of the limestone are also decomposed and soft, and both the roof and floor are very irregular, as is illustrated in the sketch.

The Poverty Flat workings are in the NW of the NE. $\frac{1}{4}$ of the same section, and about a quarter of a mile north of the last. Numerous shallow shafts have been sunk here through magnesian limestone containing much chert in thin layers. One such layer of chert one foot thick was encountered at a depth of 10 ft., composed of very white, fragile shattered chert; under this the galena was found in pockets in the limestone. Some calamine was also found here, but is not abundant. Since the opening of these mines in 1890, about 15 tons of ore had been taken out at the time of inspection in 1891.

CRAWFORD COUNTY.

A large number of mines have been worked in Crawford county, and mining began here as much as sixty years ago, but the production has been comparatively small, and none of the operations have been on an extended scale. Developments have been confined almost entirely to the eastern half of the county. Only at a few points has work been done during recent years, and, hence, the Survey has had few opportunities for examination. The following descriptions are, thus, based partly upon original observations of the writer, partly upon descriptions kindly furnished by Dr. W. A. Metcalf, of Steelville, to whom the Survey is much indebted for assistance rendered in many ways, and partly upon the early published descriptions of previous reports.

Mineral Hill mine.—This group of diggings occupies portions of sections 32 and 33, of township 46 N., 2 W. This is about the center of what have been the more productive mines of the county. Work was in progress here about 1836, and, at times, as many as 500 men have been employed. The total production up to 1856, according to Mr. Engleman, amounted to about 500 tons. He described the diggings as shallow, and as in the surface clay. On adjoining land, a crevice in magnesian limestone was encountered, running ENE, containing galena in a sheet, and iron ore in red clay. In the same section, another crevice, 3 to 4 ft. wide, was worked to a depth of 60 ft., and for 600 ft. along the strike; it also contained galena and other; layers of chert extended entirely across the crevice. Ore was also found in caves.

Williams mine.—This mine was also in section 32 of the same township. It was first opened in 1851, and produced up to 1854, nearly 200 tons of ore. During 1864 to 1870, about 25 tons more were produced. It is described as consisting of numerous shafts and tunnels on a line running about NE.-SW. Three crevices or pipes were recognized, from 25 to 30 feet apart, which were normally from 2 to 8 feet wide and 3 to 4 feet high, though at one point a width of 40 feet and a height of 18 feet was exposed. The galena was bedded in red clay, together with pyrite and other.

Hibler diggings.—These are in the NE. $\frac{1}{4}$ of section 35, same township. Galena was found loose in the clay, in crevices or pockets, and also in thin sheets in magnesian limestone. Between 1868 and 1875, about 50 tons of lead ore were produced.

Rich Hill diggings.—These are in the SW $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 33. The galena was found in the clay and in a few thin veins in the magnesian limestone. Since 1873 about 100 tons of ore were produced.

The Sappington, Darby, Clarke and Isgreeg mines.—These constitute a group of mines immediately south of the last, in the northern tier of sections of township 39 N., 2 W. The ore was found in a sandy, magnesian limestone, with layers of chert, and occurred in small crevices and pockets and as float mineral in the clay, associated with iron pyrite. Between 1862 and 1875, about 75 tons of ore were produced.

Ransom or Hopkins diggings.—These mines are in section 15, township 48 N., 2 W., and are consequently about 10 miles south of the last. They constitute the center of another group. The ore occurred here in sandy magnesian limestone, near a contact with sandstone. Galena was found in sheets 5 ins. thick and 3 ft. wide, lying horizontally and extending in an easterly direction.

Fort diggings (M).—These were discovered in 1840, and have yielded since about 150 tons of lead ore, as well as some blende and smithsonite. The ore is found in clay openings between beds of magnesian limestone. Drifts extended into the hillside 75 to 100 ft. The openings, as thus followed, grew smaller and smaller or "closed down," until only a narrow and generally barren crevice remained. The adjacent rock is generally very soft and of a sandy texture. Considerable tallow was found associated with the ore.

Harman mines (M).—These are about a mile and a half northeast of the last, in section 21 of the same township. The rocks and the mode of occurrence of the ore are similar. About 50 tons of lead ore have been mined.

Kings Mountain mines.—These were first opened about 1859, and have been worked at intervals since. They are in section 33. About 150 tons of ore have been taken from shallow shafts. Recently, a shaft has been sunk and a tunnel driven here, located as shown in the adjoining figure. The shaft

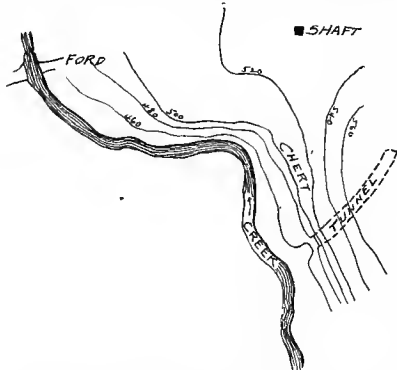


FIG. 239. The Kings Mountain mine.

was about 75 ft deep, and encountered a small bunch or pocket of galena and barite at the bottom. This is at about the same horizon as the face of the tunnel, where similar bunches of ore were seen to occur at rather wide intervals along a stratification plane. Patches of chert occur in the limestone. A drill-hole sunk 100 feet below the bottom of the shaft penetrated limestone exclusively almost the entire depth, though some chert was encountered about 70 feet down.

Lead Mountain mine (M).—This is on the adjoining forty to the east of the Kings Mountain mines. The Montray mine is immediately north. The yield in recent years was about 25 tons, and large amounts were produced in early days, of which there is no record. At Lead mountain, the galena occurred in horizontal sheets, between beds of limestone and associated with barite. In the Montray, the galena was found principally in crevices, with some blende and smithsonite.

The Matthews mines (M).—These are in section 11, township 37 N., 2 W. The ore was found loose in the clay. About 10 tons were mined.

Stanford mine (M).—These diggings are in section 8 of the same township. The galena was mined in large masses, lying loose in the clay. About 5 tons were produced.

Green's Hill mine (M).—Lead ores were discovered here in 1858, in section 6, township 36 N., 2 W. About 55 tons have been produced. The mines are situated on a high hill, capped by sandstone. The ore is found mostly in the clay beneath the sandstone and above the limestone, also in crevices extending into the limestone; it is generally associated with broken chert.

Eaton mine (M).—This digging is in section 10, township 36 N., 3 W. Lead ore was discovered here in 1890, in the bed of Dry creek. A broken bed of chert above a broad surface of limestone was exposed, and the ore was found in a narrow opening between the two. It extended in all directions, so far as explored, without diminishing in thickness. Some barite is associated with the galena. About 3 tons of ore were mined.

Cole diggings (M).—These are in section 34 of the same township. They were discovered long before 1860. About 100 tons of ore have been produced. The limestone is free from chert and drusy quartz, and can be readily penetrated by a diamond drill.

Arthur mines (M).—In sections 17 and 18 of township 36 N., 4 W., are diggings which were opened in 1863. About 65 tons of lead ore have been taken from the surface clay. One large mass of galena was dug out weighing over 2 tons. The limestone is of a bluish-gray color, entirely free from chert, and with occasional specks of disseminated galena.

In addition to the developments thus far described, lead ore has been mined at a number of other localities, and lead and zinc ores have been found and some prospecting has been done at a still greater number. Such occur in the northwestern part of the county near Maries. For the eastern part, Dr. Metcalf furnishes us with the information of the following table:

LEAD AND ZINC DEPOSITS OF MISSOURI.

NOTES ON MINES OF EASTERN CRAWFORD COUNTY.

Location.	Name.	Year opened.	Years operated.	Lead ore produced.
37 N., 2 W., section 14.	Usury	1871.....	Early years..	Tons. 5
38 N., 3 W., " 11.	Lockhart. ....	.....	.....	Only a little
39 N., 2 W., " 5	Luke Bluff.....	1865.....	At intervals..	10
40 N., 2 W.....	Coffee.....	Before war	"	125
40 N., 2 W., section 28	Sullivan.	1860.....	"	30
" " 31.....	Carter	1890.....	1890.....	5
" " 32	Soulard.....	1875.....	1875, '78, '92..	120
" " 33.....	Romine.....	1860	Early years...	100

JEFFERSON COUNTY.

Mining in Jefferson county has been principally along the southern and southwestern borders, though considerable amounts of ore have been obtained in the central portions, a few miles south and a few miles west of Crystal City. Along the southern border, the mines extend across the line into St. Francois county, but these will be described here, nevertheless, as they belong properly to the Jefferson county group.

THE VALLE MINES GROUP.

This group of mines includes a large number of shafts and shallow pits distributed over the northeastern sections of township 38 N., 4 E., and over the northwestern sections of township 38 N., 5 E. In this group we include the Valle mines proper, the Perry, the Bisch, the Tarpley, the Garatee, the Corn Stalk, and other mines of this vicinity. Work was first begun here about the year 1824, and the deposits have since yielded large quantities of both lead and zinc ores. Many figures of production of early years have already been published, to which reference is made in the chapter on statistics. In addition, we introduce the following tables, furnished by Mr. Felix Rozier, president of the company:

Lead smelted at Perry mins, 1855.....	75 tons.
" " 1856.....	130 "
" " 1857.....	78 "
" " 1858.....	101 "
" " 1859	118 "
Total	497 "

LEAD MADE INTO FIGS BY THE VALLE MINES.

<i>Years.</i>	<i>Tons lead.</i>	<i>Years.</i>	<i>Tons lead.</i>
1862	284	1879	161
1863	263	1880	135
1864	236	1881	131
1865	296	1882	105
1866	398	1883	99
1867	326	1884	150
1868	311	1885	337
1869	205	1886	494
1870	239	1887	440
1871	163	1888	258
1872	133	1889	242
1873	167	1890	209
1874	253	1891	261
1875	253	1892	550
1876	162	1893	825
1877 (estimate A. W.)	180	Total	8,519
1878	203		

SHIPMENTS OF ZINC ORE FROM THE VALLE MINES.

<i>Years.</i>	<i>Tons zinc ore.</i>	<i>Years.</i>	<i>Tons zinc ore.</i>
1870	2,577	1883	2,210
1871	2,500	1884	2,210
1872	2,000	1885	1,856
1873	2,200	1886	1,735
1874	1,328	1887	2,562
1875	2,500	1888	2,415
1876	3,938	1889	2,245
1877	3,986	1890	2,678
1878	3,244	1891	2,100
1879	2,239	1892	2,026
1880	1,973	1893	1,225
1881	2,150	Total	55,970
1882	2,073		

Up to the present date, the mines have produced about 38,000 tons of lead ore and about 62,000 tons of zinc ore. The latter consists mostly of the carbonate, smithsonite—calamine and blende being comparatively rare.

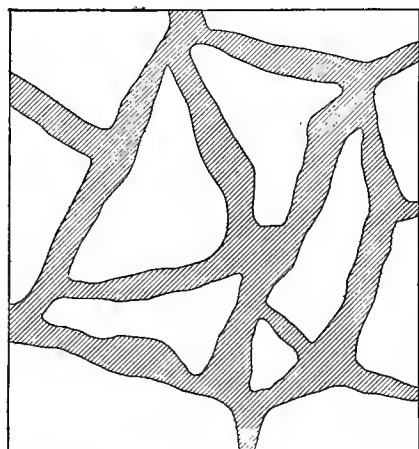
The abundance of zinc ore here is especially remarkable, when the fact of its entire absence in the closely adjoining Bonne Terre deposits is considered. Further, the prevalence of chert, drusy quartz and other forms of silica throughout the country rocks, would warrant the expectation of finding more silicate of zinc than exists. The contents of zinc ores may be judged of from the following results, kindly contributed by Mr. Rozier.

ANALYSES OF SIX DIFFERENT SAMPLES OF ZINC ORES FROM THE VALLE MINE.
(*Chauvenet & Blair, Analts.*)

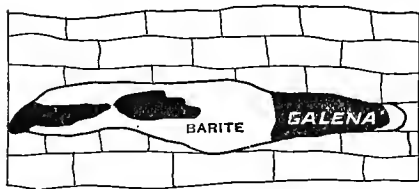
	Oxide.	Metallic zinc.
1. Mixture of Carbonate and Silicate.	56.90	45.68
2. "Clinker"-Carbonate	58.98	46.83
3. " "	59.93	48.06
4. " "	51.73	41.50
5. "Clinker"-Carbonate and oxide of iron.....	48.22	38.67
6. "Clinker"-Carbonate.....	56.84	45.55

The deposits occur here in a crystalline, white magnesian limestone, of open texture, with numerous small cavities lined with dolomite crystals. In this rock, drusy quartz and chert are found, though some exposures are entirely free from such.

Most of the older workings are now abandoned, and comparatively few mines are accessible for study. Several of these were visited by the writer in 1892. The following descriptions illustrate the modes of occurrence of the ore as then observed.



PLAN.



SECTION.

FIG. 240. Plan and section of ore channel at the Corn Stalk diggings.

The Garatee mines.—These mines are located about a mile and a half northwest of the railway tunnel, somewhere near the southeastern corner of section 1, township 38 N., 4 E. Several shafts have been sunk here. The workings of No. 6 were examined. This was about 135 ft. deep, and three runs of ore were encountered at depths of 65, 95 and 135 ft., respectively. The shaft was sunk in a chimney or opening, and no rock was encountered down to the upper run of ore. This consisted of a net-work of channels lying in an approximately horizontal position, similar to the occurrence of ore described at the Palmer mines, Washington county, and like those at the Corn Stalk and Valle mines, next described. These channels contained a large amount of red clay. The ore was principally galena, enclosed in barite; some smithsonite is also found. With these occur calcite in large crystals, pyrite, and some limonite. The ore of the other runs is found in similar net-works of channels; these are connected at times by vertical chimneys. The channels are frequently not over 1 ft. thick and a few feet wide, but they often expand to cave like dimensions.

The Corn Stalk diggings.—These were shallow pits at the time of inspection, and the deposits had been quite recently opened. They are located about half a mile northwest of Valle mine post-office, and consequently about in the NW. $\frac{1}{4}$ of section 5, immediately adjacent to the railway track. The galena was first encountered in the surface clay in the railway cut, lying directly on the limestone country rock; thence westward,

with the rise of the hill, it extended under the rock also. Shafts to the depth of 30 ft. had been sunk at the time. The ore was galena, in large masses, associated with and imbedded in barite, as is shown in the adjoining figure. Red clay is also found with the ore. These materials occur in a net-work of horizontal runs, as illustrated in figure 240; they were confined to one plane of stratification so far as developed at the time. The channels were of flattened, lenticular sections, being normally 12 to 18 inches thick and about 3 ft. wide. Some pyrite and some calcite were found, and a good deal of ilmonite adhered to the galena. The rock enclosing the ore is normally a very light-colored, crystalline, magnesian limestone: but near the contact with the channels it is softened and sandy. About fourteen openings had been sunk in an area of less than 15 acres.

The mines south of these, along the hill-side through which the railway tunnel is cut, operated similar bodies of ore, though they differed from those described, in containing less barite and more amethystine. Very little, if any, blende or calamine is produced from these mines.

The Valle mines—The Valle mines were examined by Dr. Litton in 1854. They were situated in sections 7 and 8, township 38 N., 5 E. They were located on what was known as the West hill. Ten shafts had been sunk, of which the deepest was 170 ft. The ore was found in openings or crevices, connecting with each other, and filled with broken rock, clay and galena. Three series were recognized, the first and second about 20 feet apart, and the third, or lowest, 8 ft. below the second. All work at the time was conducted in the second series. The adjoining map is reproduced from an illustration published in Dr. Litton's report. It was prepared from actual surveys, and is especially valuable as showing the exact shape of these deposits.

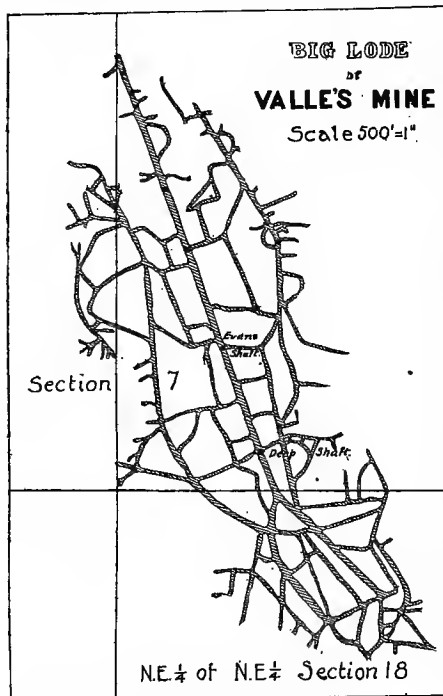


FIG. 241 Map of the Valle mines.
From Litton report, 1854.

were correspondingly poor. The shafts were sunk in from 10 to 30 ft. of clay and decomposed rock, under which magnesian limestone, solid and siliceous, was penetrated to the bottom of the shaft.

The McCormick shaft was in section 11, of the same township, in the NE. $\frac{1}{4}$. The shafts were 85 and 65 ft. deep. At the bottom, a series of openings like the last described was encountered.

Tarpley mines.—The Tarpley mines were in the NE. $\frac{1}{4}$ of section 11, township 38 N., 4 W. The deepest shaft was 180 ft., passing through 40 ft. of red clay and then into magnesian limestone. Two series of openings, 15 ft. apart, were encountered. They were each filled with galena and

Perry mine.—The Perry mine is in the E. $\frac{1}{2}$ of the NE. $\frac{1}{4}$ of section 18. In 1859, eight principal shafts had been sunk, the deepest being 165 ft. Galena was found in small caves and openings, of which there were four series, with intervals of 18 to 45 ft. between. These were connected by vertical chimneys. The second series was the most worked. These openings were filled with clay, loose rock, galena, blende and amethystine, all thoroughly mixed. Tallow clays of white and reddish colors were found in beds and along seams. Much of the ore, called dry bone here, was a mixture of galena and of silicate and carbonate of zinc.

Bisch mine.—The Bisch mine was located in the W. $\frac{1}{2}$ of the NE. $\frac{1}{4}$ of the same section. Ten shafts had been sunk here, the deepest reaching 105 ft. Two series of caves were recognized with an interval of 20 ft. between them. The ore channels ran in all directions, and those of the two series were connected by chimneys. It was observed here that, when those of one series were rich, the channels above or below

barite. Featherstonehaugh, in 1836, describes what must have been the same mines, as a gallery, 100 ft. from the surface, containing broad veins of bright galena in a paste of waxy clay; one opening, 40 ft. wide and the same in height, was filled with this red clay, and contained plates of galena at the bottom. At a depth of 80 ft., a horizontal bed of galena was found, and another at 110 ft. These were about 1 ft. thick, and were accompanied by numerous subordinate veins and threads. They were uniformly horizontal, but a "Main channel" was encountered, standing in a nearly vertical position. This was about 18 inches wide, and its course was NNE. The horizontal deposits he regarded as lateral jets from this main lode.

Among other mines in this vicinity we may cite: the Poston & Tyler, about half a mile southwest of the Tarpley, the Boggy's diggings, about half a mile east of the last, and others about the present Valle mine and postoffice. They are very numerous, and it is impossible to describe or refer to all. The descriptions already given will suffice, however, to illustrate the mode of occurrence of the ore.

THE MAMMOTH-FRUMET GROUP.

Along Big river, below the crossing of the Iron Mountain railway, and principally on the northern side, are a number of mines for a distance of some 10 miles from the railway. Prominent among these are the Mammoth and Frumet, from which is derived the name of the group. Gray's mines here were worked probably before 1830. The Mammoth mines were opened in 1843, and in the next 7 years yielded 2500 tons of ore. The Frissel mines of this group were discovered in 1842. Work at the Frumet mines was not begun before the early seventies. These deposits all occur in magnesian limestone, and are in many respects similar to those last described. A few of the openings have been worked during past years, and some of these were visited by the writer.

Lee's diggings.—These are situated in the NW. $\frac{1}{4}$ section 13, township 39 N., 3 E. Work has been conducted here for a good many years at different intervals. Much of the ore was dug from shallow pits along the outcrop of the run of ore. At the time of inspection, in December, 1898, a shaft 80 ft. deep had been sunk through solid limestone to the ore body. This consisted of a network of nearly horizontal channels similar to those already described. These follow stratification planes, but dip with the rocks a few degrees to the N. Two runs were recognized here about 3 ft. apart, the upper being principally worked. The ore channels were from 6 to 14 inches thick and from 3 to 14 feet wide, and were sometimes filled entirely with galena. The galena is, however, generally enclosed in barite, and sometimes has pyrite underneath it. Perhaps one-fourth of the ore taken out is blende, which is thrown away at present on account of the difficulty of separating it from the associated barite. Some clay openings are found, but no vertical crevices were seen. The ore stratum rises gradually to the surface, and early surface diggings were along its outcrop.

The Mammoth mine—This mine is about a mile north of the last, in the NW. of the NW. $\frac{1}{4}$ of section 12. Little or no work has been done here during recent years. In 1854, Dr. Litton found it operated by shafts about 80 ft. deep. The ore occurred in an irregular series of caves, running in a general E.-W. direction. These were from 4 to 9 ft. high, from 4 to 12 ft. wide, and were connected by narrower openings. They were sometimes partially filled with clay and loose rock and ore, and often massive galena was found in large quantities adhering to the sides and tops of the caves. A line of disturbance and faulting, which we have already referred to (p. 355), is described by J. V. Phillips [169] as running immediately north of this and adjacent mines, and was believed by him to have some connection with the deposits. The mine is referred to by Christy, in 1845, as in an irregularly formed crevice, containing galena and calcite in large masses, mixed with clay and sand [234, p. 419]. Broadhead observed the following order in the deposition of the minerals here: 1) botryoidal quartz, 2) iron pyrite, 3) blende, 4) barite, 5) calcite [31, p. 106].

The Frumet mines.—These have been the scene of very large operations and of the waste of a great deal of money in poor methods of mining and premature improvements and erection of plants. During the past 25 years \$160,000 has been expended here.



BRECCIA AND STOCKWERK AT THE FRUMET MINE IN JEFFERSON COUNTY.

THE ROCK IS MAGNESIAN LIMESTONES; THE VEIN FILIND, BARITE, INCLOSING GALENA.

FIG. 1.

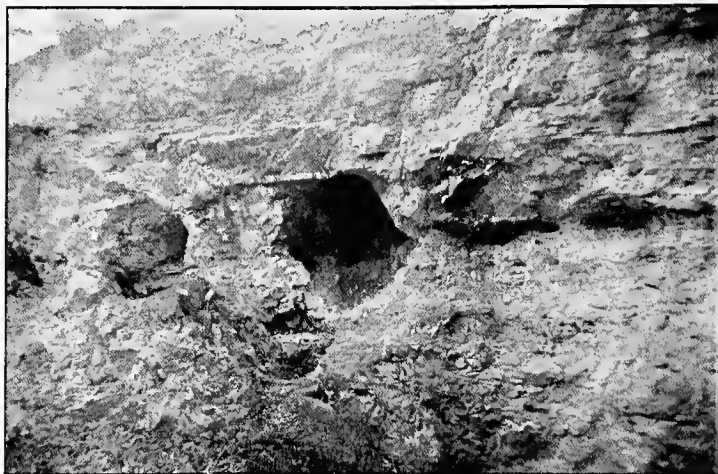


FIG. 2.



CAZIN CUT AND TUNNEL VIEWS — FRUMET.

FIG. 1. WALL OF CUT SHOWING ORE POCKETS.

FIG. 2. MOUTH OF TUNNEL.

From photograph by W. P. Jenney.

The property includes about 1300 acres, distributed over portions of sections 28, 33 and 34, township 40 N. 3 E. The postoffice here is about eight and a half miles from De Soto. Openings have been made on various parts of the property, and both lead and zinc ores have been obtained. The principal of these openings are known respectively as the Zinc mine, the Sophia cut, the Frumet shaft, and the Cazin cut and tunnel. These were all examined by the writer in November, 1893, in company with Mr. George W. Taussig, the present owner. The following descriptions are from notes taken then:

At the Zinc mine the ore has been taken out in an open cut. It consists largely of galena in barite, occurring both in crystals and in disconnected sheets. Some blende and calcite are also found, associated with red tallow oliv. These ores occur in small pockets, veinlets or sheets, running irregularly through the magnesian limestone, and also following planes of stratification. These sheets are generally not more than a few inches in diameter, and are confined to a few feet of thickness of the limestone, which preponderates greatly in quantity over the ore. The deposit may be classed as a stockwork.

The Sophia cut is about one mile north of the Zinc mine. The excavation is in the side of a hill, in thinly bedded magnesian limestone, which contains a considerable quantity of pellucid, bluish chert, concentrically banded, and occurring in lenses, thin layers and irregular masses, such as are illustrated in figure 18, on p. 336. The ore consists of galena in barite, and fills small crevices running in different directions through the limestone. Crushed rock and sand is also found along these crevices. There is no one prominent crevice, and they follow no one direction, but are horizontal and at all angles. Pyrite, in considerable quantity, is found in pieces; no red clay was seen. The magnesian limestone is of the usual granular, white kind, associated with drusy quartz, which is abundant over the surface.

A few hundred feet northeast from this cut, the Frumet shaft was sunk 140 ft. deep. It penetrated white, magnesian limestone, which contained a little barite, some little galena, and traces of blende. No ore body was, however, encountered.

The Cazin cut and tunnel.—This is a very large excavation on the top of a hill overlooking Big river. The rock is a magnesian limestone, pitted and granular, though in part shaly and brecciated. The ore is galena and blende, mostly associated with barite and calcite. It occurs in cavities or caves, 1 to 6 ft. in diameter; it is also found following certain layers of the rock; but, in other places, it follows interlacing veins through massive limestone, in true stockwork fashion; again it is found between fragments of brecciated rock. No one persistent vein or other ore body is recognizable. An attempt was made to mine the ore by an open cut; but from the face presented, the proportion of ore seems hardly to justify this course. The existing cut is very large, though partly under roof in a tunnel. Its dimensions are approximately 800 ft. in length, 80 ft. in width, 50 ft. in depth. Some pellucid chert occurs in the limestone here. The modes of occurrence of the ore are illustrated in accompanying plates. The large fresh surface in the open cut offered opportunities for illustration which were unequalled elsewhere, and they were, hence, taken advantage of to secure a number of illustrations of ore phenomena which are typical of the whole sub-district.

This property has been examined by others in the past, and has been undoubtedly damaged by the extravagant reports which have been made. Though there was probably much ore here, there is nothing in the conditions now presented at the various openings which is different from those at other mines in Washington and Jefferson counties, and the same precautions and economical methods in working the ore must be pursued in the development of this property as in others.

The "Edging lead" is described by Litton as about 6 miles north of the Mammoth, and as "Edging vein" is described by Mr. Forrest Shepherd at Frumet. They are probably the same. According to Litton, it consisted of a vertical crevice, running in a N. to S. direction, 18 to 30 ins. wide, with a vein or sheet of galena 1 to 4 ins. thick. Five shafts had been sunk here then to depths of 30 ft.

THE PLATTIN CREEK GROUP.

About eight miles south of Crystal City, on Platin creek, are a number of diggings, the principal of which have been known as the McCormick, How and Yankee lead mines. Work was begun here as early as 1824, and considerable amounts of ore have been taken out since.

The *McCormick mines* are situated near Platin Creek station, in the northwestern corner of section 7, township 39 N., 6 E. Operations were begun here in 1824 or 1825, and we find notices of the mines being worked at intervals since, up to 1875. During the last few years, work has again been resumed, and some 30 tons of ore have been taken out. According to Mr. McCormick, one shaft produced, in 1868, 150 tons of galena, and, altogether, the mine has produced about 400 tons. He states that two channels or crevices are recognized, running a little north of east, about 850 ft. apart. They have been prospected for about two miles. They vary in width from nothing to 8 ft., are normally about 3 ft. wide, and are generally filled with clay, containing masses of galena associated with calcite. The greatest depth of mining has been 150 ft., and below this, an opening was encountered, in boring, 50 ft. deeper. All of the ore is confined to the crevices, and does not extend into the wall rocks. The latter are the same on both sides, indicating no faulting.

Other minor crevices are found here, but they have not been worked. Some little zinc ore and some pyrite occur with galena.

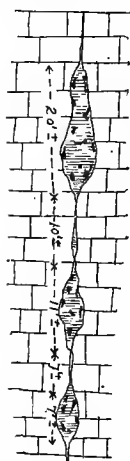
The *Yankee diggings* are in section 6, about a mile north of the last, and apparently worked the same crevice. Shumard described it as running north and south. In a shaft 70 ft. deep, the contents was seen to be galena with calcite, barite and pyrite.

How's mines, about 3 miles northeast of the last, in sections 3 and 4, near the north line, were discovered in 1840, but produced less than 100 tons of ore in the next 16 years, all from shallow pits. Mr. McCormick informs us that crevices similar to the McCormick are found here, but they contain more barite, which sometimes fills the entire space between the walls. He states that very little ore has been taken from this mine up to the present time, though a great deal of work has been done there.

THE SANDY MINES GROUP.

In this group we include a number of mines which occur in township 41 N., 5 E., west of Crystal City. The most noted of these are the Sandy mines, the Gopher and the Herculaneum mines.

The *Sandy mines* are located in the N. $\frac{1}{2}$ of section 18. They were discovered in 1824, and were quite extensively worked during the early years. In 1826, they produced 450 tons of ore, and up to 1856 had yielded 5000 tons. As examined by Litton at that time, the diggings extended about a mile in a direction somewhat east of north. The deepest shaft was 115 ft., passing first through 14 to 30 ft. of surface clay, and then into a bluish earthy limestone.



The ore in the rock occurred in a vertical crevice which expanded and contracted so that the galena was mined from a series of connected cavities, somewhat as is shown in the adjoining sketch. These enlargements were found at three different levels. The crevice remained perfectly well defined between these, however. The ore was principally galena, but some cerussite was mined, and, at times, blende and pyrite were found. Broadhead describes [81-106] the deposit as a nearly vertical fissure running N.-S., from a knife edge to 17 inches wide, with a wall-rock of magnesian limestone. This, he states, was filled with barite and galena. It had been traced for several miles. He reported two other fissures parallel to this, a few hundred feet apart.

No descriptions of the Gopher mines have been found, and they are long since abandoned. Shumard notices that much barite and calcite were mixed with the galena.

Many other diggings have been made in Jefferson county, in the vicinity of the mines thus far described, and specimens of lead ore are reported from nearly every township. The preceding descriptions cover, however, the most noteworthy, and are all which recent opportunities and the records preserved to us, make a description of possible.

FIG. 242. Ideal section of the Sandy mines lode.

THE FRANKLIN COUNTY SUB-DISTRICT.

This sub-district includes all the mines of Franklin county. They occur principally along the Meramec river and between it and the Bourboise on the north, the tract being thus not more than twelve miles wide in an east to west direction.

Some of the mines of this sub-district have been the scene of extensive operations, and large sums of money have been expended in equipment and improvements. As the history of operations already given shows, mining has been conducted here about a hundred years, and a large quantity of ore has been produced; but the promise and output in many cases have not been proportionate to the scale upon which some of the undertakings were planned. Loose methods have done much to damage the reputation of the mines.

This sub-district is pre-eminently one of vertical crevices or veins; other forms of deposits are found, but the former are by far the most important, and some are doubtless fissure veins. On the district map, the location of the principal mines is shown.

The rocks within this area are principally magnesian limestones of the St. Francois formation, containing greater or less quantities of chert, and are in other respects similar to those of Washington county. Sandstones are also found associated with the limestones. The exact number of strata and their distribution have not yet been exactly defined, and can only be so after detailed stratigraphic work is conducted here. In a general way, all of these beds dip slightly to the north, but local variations from this are observable at a number of points.

All the mines of Franklin county were examined in some detail by Dr. Litton in 1854, and later Swallow and others reported on different properties for private companies, or for individuals. During recent years the writer has made several visits to Franklin county, and has examined such openings as were accessible at the time. In these trips he has, upon several occasions, had the benefit of the company of Col. A. W. Maupin of Union, who has contributed much information concerning the past history of mining here, and also concerning the modes of occurrence of the ore in the mines now inaccessible. One trip to the county was also made by Mr. Robertson. The following descriptions are prepared from these various sources.

The Golconda mines.—These mines are situated in the W. $\frac{1}{2}$ of the SE. $\frac{1}{4}$ of section 18, township 43 N., 1 E., and are thus well north of the main mining area of the county, and exceptional in this respect. Mining was begun here in 1830, and operations were quite extensive for a number of years; some 750 tons of ore were produced. The galena was first found in surface clay, but later a crevice or fissure was encountered, which ran in a course N. 10 or 15° E., and which varied in width from 2 to 3 inches. At the time of Litton's examination, seven shafts had been sunk, none below 18 ft., however. The opening was filled with clay carrying galena and calcite. A few feet east of this crevice was a second one nearly parallel, which attained a width of 4 ft. in places. Both of these were in magnesian limestone.

Proceeding south from this, the next deposit worthy of note is about 8 miles distant, close to the Frieco railway.

The Otto and Burt shafts.—These shafts are along the western line of the SW. $\frac{1}{4}$ of the NW. $\frac{1}{4}$, and in the NW. $\frac{1}{4}$ of SW. $\frac{1}{4}$ of section 20, township 42 N., 1 E. At the time of inspection, the Otto shafts were about 130 ft. deep, and followed a crevice in magnesian limestone with a course nearly

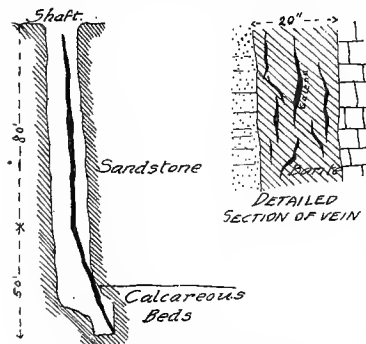
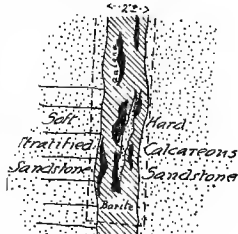


FIG. 243. Section of shaft and vein at the Otto shaft.

due N. and S. The adjoining illustrations show the conditions of occurrence as well as the contents of the crevice. The total width of the latter as exposed was about 20 inches; the gangue was largely barite. In this the galena occurred in thin, lenticular, vertical sheets or patches. Blende is associated with the galena, but also occurs separately in the barite. The rocks on the two sides of the crevice are different, showing that some movement has taken place.

The Burt shaft was about 200 ft. north of the Otto, and was 55 ft. deep. The adjoining vertical section, figure 244, illustrates the conditions of occurrence here. The vein carried a large amount of barite, but was also rich in galena.

The Cove and Short mines.—These mines are about 2 miles east of the last, both being in the NW. $\frac{1}{4}$ of section 22, same township. At the Cove mine, a vertical fissure was encountered about 6 inches wide, running N 5° E., with a steep dip to the east. This was sometimes entirely filled with galena; elsewhere it contained barite and calcite, and sometimes clay replaced these. The main shaft in 1854 was 150 ft. deep, and four others were sunk 30 to 60 ft. apart; these were all connected by levels, and the vein was thus opened for a distance of about 400 ft. The upper portion of the hill here is composed of sandstone, and the crevice was found to follow up into this and to continue ore-bearing. No evidence of faulting is reported here.



The Short mine was nearly 900 ft. east of the Cove, and between these, two crevices were recognized by Dr. Litton, known respectively as the Negro and Scott lodes, both running a little W of N. At the Short mine, a crevice, varying from one inch to 2½ ft. in width, was encountered; it ran in a N.-S. direction, and stood nearly vertical. The ore consisted of galena in barite, sometimes accompanied by blende. Three shafts have been sunk, reaching a depth of 85 ft.

About a mile south of the Short mine, in the NW. $\frac{1}{4}$ of section 27, some lead ore had been mined on land which belonged to the Mount Hope Mining company. No descriptions of these workings have been obtained. Immediately south of this, however, on the south side of the river, is a group of what have been important mines, which may be termed the Mount Hope group, which have produced to date about 8000 tons of ore.

The Mount Hope mine—This mine included several shafts and small openings, distributed over the northern part of section 3 and the adjoining portion of section 4, township 41 N., 1 E. At one point, near the eastern line of section 4, the writer observed a vertical fissure exposed in the hillside, whence a large amount of ore had been taken out. The opening was about 2 ft. wide, and the walls on each side were magnesian limestone containing much chert. These differed from each other, however, at the same levels, in evidence of faulting, which is further indicated by slickensided surfaces. The movement was probably slight. Litton described this mine as a vertical fissure, 1 inch to 2 ft. wide, running a little E. of N., the contents being sometimes entirely galena, and, at other times, galena mixed with clay and barite, and occasionally blende and smithsonite. At that time, thirteen shafts had been sunk, ranging in depth up to 135 ft., and covering a distance of about 800 ft. in a N.-S. direction.

The Evans mine.—This is described by Litton as north of and almost adjoining the Mount Hope mine. A vertical fissure was found here also, about 2 ft. wide, running nearly N.-S., and filled with clay, barite and galena, and some blende and smithsonite. Seven shafts had been sunk to depths of 120 ft., and the vein had been mined along its strike a distance of 400 ft. On the map, this mine is shown to be near the south line and about the middle of section 34, township 24 N., 1 E.

The Casswell mine.—This mine is situated about a quarter of a mile northwest of the last, in the N. $\frac{1}{2}$ of the SW. $\frac{1}{4}$ of the same section. The mine was opened in the bluff on the south side of the river. Swallow described the deposit, in his report of 1854, as a perpendicular vein, varying from 2 to 10 inches in thickness, striking N.-S., and with a slight inclination to the east. The gangue of this vein was barite, calcite and red clay, in which the lead ore occurred chiefly as galena, but occasionally as cerussite. The magnesian limestone, which constitutes the base of the hill here, is capped with sandstone, and the vein cuts through both the limestone and sandstone, as it does at the Evans mine also. Swallow expressed the belief that the two mines are on the same vein.

The Silver Lead mine.—This mine is less than a mile west of the last, and is located near the middle of section 33, township 42 N., 1 E., on a tongue of land surrounded by a loop of the river. The top of the shaft is not much above the river level. It was originally sunk to a depth of 75 ft., the upper 30 ft. chiefly in chert, the lower part in limestone. The workings extended to a depth of 150 ft., however. The lode was stripped at another point for about 75 ft. It runs nearly N. 10° E., and is about 4 ft. wide; the walls are well defined and regular, except at one point, where the

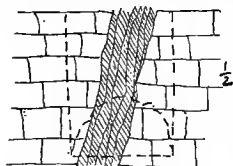


FIG. 245. Section of the Silver Lead lode.

crevice appears to be faulted toward the east for about 2 ft. This lode can be traced the whole distance between this point and the Silver Lead shaft, by means of the shafts sunk along the line. In one shaft, the section shown in the accompanying sketch was exposed. The material filling the crevice, which was here about $2\frac{1}{2}$ to 3 ft. wide, consisted of barite in approximately vertical sheets. No galena was visible. It was noticeable that the principal shafts were sunk almost on a compass course. Such shafts as were sunk on the lode had been worked for lead, and were surrounded by a pile of debris that made them readily recognizable; while others, sunk away from the lode, were soon abandoned, and are nearly obliterated. About 750 tons of ore were produced.

The Jeffries mine.—This mine is situated in the SE. $\frac{1}{4}$ of NW. $\frac{1}{4}$ of section 35, township 42 N., 1 E. Only a few shallow shafts have been sunk here, and little or no ore produced as yet. The

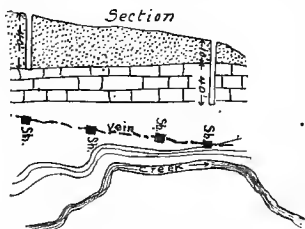


FIG. 246. Plan and section of the Jeffries mine.

shafts are upon a vein or crevice running about due N.-S. (mag.), or perhaps a little E. of N. The thickness of the vein is reported to range from 8 to 12 inches. Four shafts in all have been sunk, varying in depth from 30 to 50 ft. Their locations are somewhat as is shown in figure 246. The vein extends vertically from the limestone in the lower portion of the shaft up through the sandstone of the upper levels; no faulting is exhibited. In the sandstone the principal gangue is barite, while calcite is more abundant in the limestone. Some blende is also found.

West of this group there have been a few diggings on the west bank of the river, but no observations of these are recorded.

The Northumberland mines.—These mines are situated in the NE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 5, township 41 N., 1 E. Shafts were sunk here on a vertical vein to a depth of about 100 ft. The strike

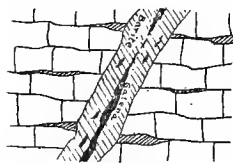


FIG. 247. Section of the Northumberland lode.

of this vein is a little W. of N. When examined by the writer, it was seen to be about a foot thick, and consisted of a central band of galena, about 4 inches thick, with barite on each side carrying blende in patches. This is illustrated by the adjoining ideal sketch. The east wall was seen to be harder and to contain more chert, and is thus different from the west wall. This indicates a certain amount of vertical movement or faulting. The vein pitches a little from the vertical toward the west, which is locally considered a favorable indication. It is estimated that about 1000 tons of ore have been taken from this mine. Shafts extend into the section on the north.

Proceeding about two and a half miles southeastward from the Northumberland, we come to the best known and most important mine in this sub-district, *i. e.*, the Virginia mine.

The Virginia mine.—This mine is located principally in the NW. $\frac{1}{4}$ of section 16, township 41 N. 1 E. It was discovered in 1834, and has been the scene of large operations since. To date, over 13,000 tons of lead ore have been produced. According to Col. Maspin, the total depth reached has

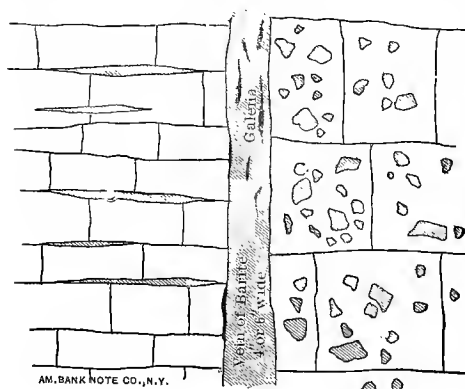


FIG. 248. Section of the Virginia lode.

been 480 ft. No work has been done here now for a number of years, and, though twice visited by the writer, nothing but surface exposures could be seen. Remains of a large furnace and hoisting plant are still extant, and numerous shafts and pits attest the extent and vigor of past developments. What is known as the Inge shaft is close to the old furnace, and is reported to have been 325 ft. deep. From this, the pits extend in both directions, along a course about N. 20° W. (mag.), and show the direction of the fissure, though this is probably somewhat sinuous. In an old shaft, about a quarter of a mile south, the vein consists of barite, 18 inches to 2 ft. thick. About 100 ft. farther south, another pit exposes the section represented in figure 248. The crevice is here filled with a vein of barite, 4 to 6 inches thick, containing patches of galena. The barite is of a dark purplish color, resembling some varieties of chert, and exhibits slickensided surfaces in places. The east wall of the vein consists of massive, magnesian limestone, with chert, which latter does not appear in layers, but in numerous fragments, as if brecciated. The west wall consists of magnesian limestone, thinly bedded, with layers of chert alternating with the limestone. These conditions are unmistakable evidences of faulting. The amount of throw could not be determined with the opportunities now afforded for examination. The great depth to which the vein has been followed is suggestive of considerable movement, yet the comparatively undisturbed condition of the wall-rocks immediately adjacent is opposed to this.

This mine was described at some length by Litton in 1854, and as seen by him, the deposit occurred in a vertical fissure running nearly due N.-S., which had been traced and worked for a distance of over a mile. The width of the fissure varied from 1 to 15 ft., and it traversed magnesian limestone. It was filled with clay and barite, the latter both crystalline and amorphous, in which the galena was imbedded. Blue crystals of barite have been found in the dump-piles by the writer. At one point, between what were known as the Engine and North shafts, Dr. King, who also examined this mine, describes a "vast cavern" extending from the first level almost to the surface,



FIG. 249. Longitudinal section through the Virginia mine in the plane of the vein.

with an average breadth of nearly 5 ft., and from 50 to 100 ft. in height; this, he states, was nearly filled with pure galena. Figure 249 illustrates the extent of developments at that time.

During the first year of operations, between 200 and 300 miners were at work on separate parcels of land, the property belonging then to the public school lands. It was worked under some such conditions until 1844, when the Meramec company obtained a lease. This company commenced energetically and continued work for two years, but then ceased on account of business embarrass-

ments. Operations were not resumed up to 1854, and by that time Dr. Litton estimated that about 5000 tons of ore had been produced. After this date, according to Col. Manplin, it was worked by leases up to 1873, when the total yield rose to about 12,500 tons. In the latter year, it was sold to a New York company, and since that time about 625 tons more have been produced.

The diggings of the Virginia lands extend nearly down to the Meramec river. Beyond this stream to the south, lead ore has been found at a number of other localities, in sections 21 and 28, as indicated on the map. At the *Petroleum Lead mine*, considerable ore has been taken out in section 21, amounting to 625 tons, according to Col. Manplin; in section 28 there has been only prospecting. The *Giles mine*, in section 32, has yielded about 150 tons.

The Skinner mines—These are located about two miles northwest of the last, in section 30, township 41 N., 1 E. As examined by the writer in 1892, a number of pits were seen following a course N. 12° W. (mag.), up and down the hills. At one point, in a small ravine between two hills, a vein was exposed in the bed of a branch. This was about 4 inches thick, following the above course. It consisted of barite, containing galena in scattered crystals. The crevice traversed magnesian limestone without faulting. In the country rocks, joint-planes were observed following the same course. Diggings along this same belt are reported to extend through sections 19 and 31, thus covering a distance of a mile and a half or more. A company operated this deposit during 1865 and succeeding years, and about 125 tons of ore were taken out. The shafts were sunk to depths of about 75 ft.; at the bottom, the vein of galena was about 4 inches thick.

Other diggings, known as the Girard, Barthold or Jeffries, Massey, Wood and Gallenkamp and others have been worked near here, and according to Col. Manplin's estimates, have produced about 50 tons of ore.

The Vieman mine.—These recent diggings were opened in the south river bluff, near the middle of the S. $\frac{1}{2}$ of section 7, and are thus between 2 and 3 miles north of the Skinner. As examined by the writer in December, 1893, three drifts were driven about 20 ft. above the river bottom, the longest being about 150 ft. Galena was found here in lenses and pockets, mostly following the stratification, and within a vertical range of not over 10 ft.; small gasch veins occurred transverse to the bedding, containing some barite and calcite. These are in a dense, hard country rock, consisting of white chert and very siliceous magnesian limestone, often largely oolitic. The northmost drift was

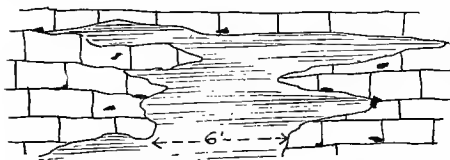


FIG. 250. Section of cave at the Vieman mine.

in an opening in the limestone, which was filled largely with red clay, the walls of which were very irregular, as is shown in figure 250. Galena is found in the limestone, and also some blende associated with barite.

West of the Vieman mine, in the next township, are a number of diggings, including the *Generally*, from which more or less lead ore has been taken. No descriptions of these are, how-

ever, obtainable. In the southwestern portion of this same township, 41 N., 1 W., are a number of mines which have yielded considerable quantities of ore.

The Darby mine—This is situated in the SE $\frac{1}{4}$ of section 20, on the north side of the river. The deposit is described by Litton as occurring in a large cave or chimney, which extended to the surface, and was filled with clay, broken rock and ore. No developments have been made here recently, and opportunities for examination do not exist at present.

The Farrar mine—This mine is located in the NE $\frac{1}{4}$ of the SW $\frac{1}{4}$ of the same section. It is described by Swallow [217-p. 25] as being about 80 ft. above the valley. The ore occurred in "horizontal" lodes or layers between veins of limestone. The galena was found in fine, large crystals, associated with calcite imbedded in red clay; a thin sheet of iron ore rested on top of the clay, beneath the roof rock. Adjacent to this opening, the limestone was decomposed and granular, and was called sandstone. Several tons of galena were mined here in 1859 and 1860.

South of the river, in the same section, are a number of other excavations which are, however, little more than prospects. Of these, the *Cove mine*, in the SE. and SW. fractional quarters, was examined by the writer. A good many shafts were sunk here, a few of which extended into the rock. In one drift, a thin lenticular streak or sheet of galena was seen in a vertical position, running E.-W., through hard, siliceous-looking magnesian limestone.

In the sections immediately south and east of this—i. e., in 28, 29, 32 and 33—are a number of other diggings, from which some lead ore has been obtained.

The Thomas mine.—This is located on the north line of section 5, township 40 N. 1 W. It is here that the first operations in the county are reported to have been started by the Spaniards, before the Louisiana purchase, and a great deal of work was done in later years. Since 1840, it is estimated that at least 7500 tons of lead ore have been produced. Records of the conditions of occurrence of the ore or descriptions of the mine have not been preserved, and no opportunities are now afforded for making this omission good. We, hence, have to be content with this meagre notice.

In the vicinity of the Thomas are the *Clark, Appleton, Gallagher, Booth, Jeffries, Pickels* and the *Harrington mines*. Some of these have produced considerable quantities of ore, and some are mere prospects. Their total production is estimated by Col. Maupin to be 1250 tons of lead ore.

Proceeding about seven miles north, we reach another group of mines in the northwestern corner of township 41 N. 1 W.

The Elliott mine (R).—This mine is located in the middle of section 6. The diggings have been mostly shallow. According to Dr. Litton, the ore, which was entirely galena, occurred in three parallel ranges, 15 to 20 ft. apart, running in a general northeasterly direction.

Several shallow pits were sunk, and one shaft to a depth of 40 ft. The lead was found in the residuary clay, in various sized masses. These mines have been worked at irregular intervals, and more or less exploration carried on since 1855. In one shaft, where the rock approached the surface, a crevice about 40 inches in width was noticed with quite well-defined walls; its course was N. 10° E. Several shafts have been sunk since on a continuation of this lode. In the southeastern part of the section, Messrs. Miller have been prospecting, and have opened up a "run" of galena in the limestone. It is different from the crevice found here, in that it has no well-defined walls, simply being a mineralized portion of the limestone, and it bears nearly E. W. instead of N.-S., which is the usual course of lead-bearing crevices in the county; moreover, there is no harite associated with the galena in the "run" just described. As yet very little lead has been produced.

A number of other diggings have been worked immediately about this mine, and have been variously known as the *Highland* and *Kerr* mines. North of this are the *Hamilton* and *Patton*, extending as far as the Bourboise. These, together with the *Elliott*, Col. Maupin estimates as having produced as much as 2000 tons of ore, principally from surface clays, though in part also from crevices and chimneys in the limestone. Shafts have been sunk to depths of 110 ft., and tunnels have been extended into the hill as much as 200 ft.

The Maupin mines.—These are located in the southeastern part of section 36, township 42 N. 2 W., and are thus about a mile northwest of the Elliott. The openings have been mostly shallow, passing first through surface clay, and then through an open cellular chert, 5 or 6 ft. thick, down to the magnesian limestone. The ore occurs in the clay and in openings in the limestone, which are chimney-like and also flat. No vein-like body is recognized, nor can any special course or trend of the ore be observed. More or less ilmonite is associated with the galena. Large masses of sandstone occur over the surface here, containing small particles and angular fragments of the chert.

The Cruz diggings.—These are in the NE. corner of the same section as the last, and the character of the deposit is similar. A large mass of honeycombed chert was observed. The ore was seen in isolated cavities or in masses, in a siliceous, magnesian limestone.

The Shotwell mines—These are near the center of section 32, township 42 N. 1 W., and are thus about one and a half mile northeast of the Elliott. The ore deposit is similar to those of the last two described localities. Recently, a shaft has been sunk to a depth of 90 ft. here, but was filled with water at the time of visit, and could not be examined. Crystallized barite is found with the lead ore here. During two years of operation, some 750 tons of ore were produced, according to Col. Maupin.

In sections 28 and 33, just east of the Shotwell mines, are a number of diggings from which more or less lead ore has been taken. In the SW. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 33, same township, Swallow [217, p. 40] describes shafts passing through the sandstone into the limestone, in which ore was found in caves and chimneys and crevices, associated with clay and iron ore, between depths of 30 and 40 ft. About 400 yards west of this, across the valley, he refers to another mine and several shafts in which galena was found, with clay, in cavities in the limestone. In the NW. $\frac{1}{4}$ of

the SE. $\frac{1}{4}$ of section 28, he describes veins and stockworks of galena and barite, in some of which the galena was one inch thick. From his descriptions, lead ore seems to have been found abundantly in sections 28 and 32.

North and west of these are numerous diggings on both sides of Bonrboise river. The *Peninsula mines* are among the most important of these. They were distributed over sections 15, 16 and 17. Mining was in progress here nearly 60 years ago. Operations were chiefly by individuals up to 1868, when a company took hold, but did little work on account of business complications. Since 1875, nothing much has been done here. Col. Maupin estimates that from this and adjacent diggings about 1000 tons of ore have been produced.

The *Jack mines* are in the middle of section 24, township 42 N., 2 W ; in close proximity to these were several others, which, together with the Wengler mine, about six miles south, produced 250 tons of ore.

At a number of other points in the county, as is exhibited on the map, lead ores have been dug. Those described or referred to are, however, the more important, and, collectively, they give a very exact idea of the nature of the ore bodies.

It is much to be regretted that nobody was on hand to critically study the conditions disclosed in the deep workings of some of the mines which have been operated in the county. Such observations would be of great value now in determining the question of the probable vertical extent of the ore. Opportunities for such examinations can now be acquired only through expensive cleaning out and pumping.

OUTLYING LOCALITIES OF SOUTHEASTERN MISSOURI.

Beyond the limits of the sub-districts thus far described, and even outside of what we have defined as the southeastern district, there are a number of localities where lead and zinc ores have been found.

In Iron county, in the western and southern portions, occurrences of lead ores are reported.

In Perry county, principally in the vicinity of Silver Lake, more or less mining has been done during the past 50 years. What were known as the Wilkinson diggings, in the NE. $\frac{1}{4}$ of section 29, township 35 N., 9 W., were opened as early as 1827, according to Shumard, and were worked for about a year, when they were abandoned until 1839, some 20 tons of ore having been produced. They were worked again in 1839, and abandoned after this until 1856. Between 1868 and 1872, there are also records of operations in the county, and during the past few years new developments have been made. In all, probably not over 500 tons of lead have been produced. Shumard describes the galena as occurring in masses in red clay and in openings in magnesian limestone. Mr. Robertson recently visited the county and examined certain openings in the vicinity of Silver Lake. The following are the notes obtained by him:

At the McCormick mine, in section 35, township 35 N., 9 E., a number of shafts have been put down. One of these was 117 ft. deep and passed through the following section, according to the report of Mr. Geller:

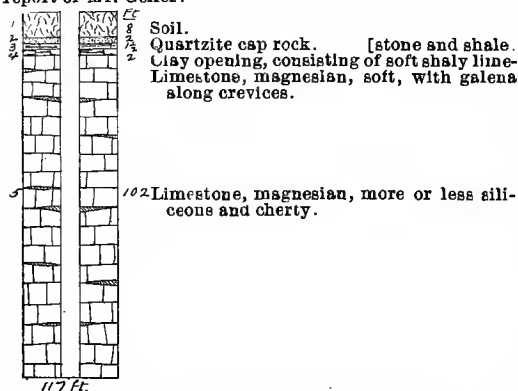


FIG. 251. Section of a shaft at McCormick mines.

In section 13, township 39 N., 6 E., and in the adjoining section 19 to the east, was the Robbins lead mine. The deposit is described by Prof. A. D. Hager, in ms. notes in the Survey office, as a vertical vein running a few degrees W. of N. and traceable more than a quarter of a mile. The contents consisted principally of limonite with a sheet of barite in the middle; some calcite was also found. The vein in no cases exceeded two or three inches in thickness. Lead ore was not found in paying quantities, though half a dozen shafts were sunk.

About four miles southeast of this, zinc ore has recently been discovered at what are known as the Drury zinc mines.

In the southern part of the county, adjoining the Perry county mines, on the upper waters of Saline creek, small deposits of lead ore have also been discovered and worked. None of these developments have been extensive, however, and, at the time the county was visited, opportunities were not presented for their examination.

South of the district, in the northern part of Cape Girardeau and Bollinger counties, occasional patches of galena are found in the limestone, and, more frequently, loose in the clay or along the beds of small streams. No mining of these ores has, however, been undertaken, and the conditions are not such as to warrant much outlay or to encourage (hope in the search for these ores here.

The galena is taken from No. 4 of this section, which is more or less decomposed, and is encountered at depths varying from 8 to 20 ft. No workable ore has been found below this. The mines were worked spasmodically, and no estimates of their production could be obtained. There are quite a number of shafts in this vicinity, and many have raised a considerable quantity of ore.

In Ste. Genevieve county we have already referred to the Avon mines. In addition, however, both lead and zinc ores are known to occur in the northern part of the county, between Establishment and Isle Le Gria creeks.



VIEW OF THE EINSTEIN MINE.
From photograph by G. E. Ladd.

The Einstein Silver Mine.—Before concluding with this district, it seems appropriate to add a few remarks concerning the Einstein silver mine in Madison county. This mine is situated on the right bank of the St. Francois river, in section 12, township 33 N, 5 E. The deposit is unique and of special interest in that it consists of a well-defined vein of silver-bearing galena traversing Archean granite. No such deposit occurs elsewhere in Missouri or in the Mississippi valley.

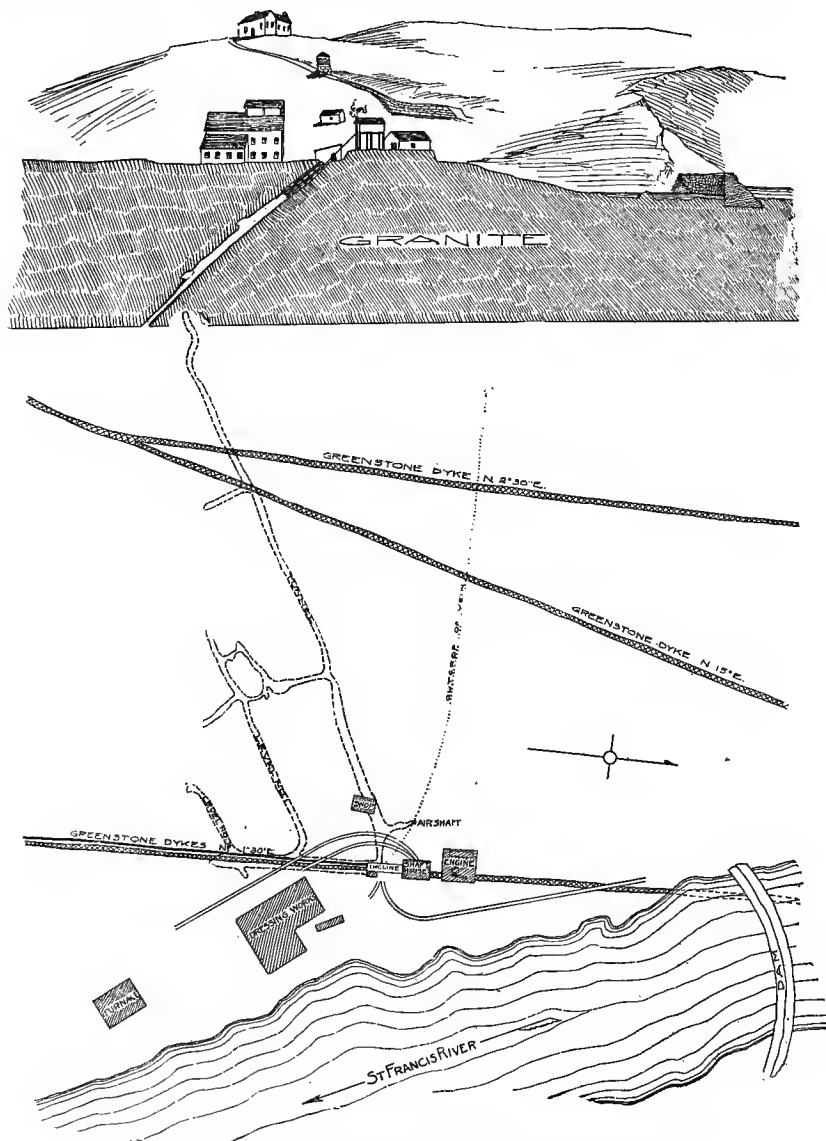


FIG. 252. Plan and cross section of the Einstein silver mine.
From surveys under the direction of Prof. W. B. Potter.

Various accounts exist, some of them doubtless mythical, of the early discovery of this deposit nearly 70 years ago. It appears that some work was done here about 1855, and, later, the property passed into the hands of Messrs. Knox and Einstein. The first systematic operations appear to have been started about 1875, in the interests of these gentlemen. About 1879, a stock company was formed and operations were greatly extended. A substantial dam was built across the river for water power, which still remains, and is illustrated in the plate. A tunnel was driven about 20 feet long and an incline sunk to a depth of 180 ft., and between 200 and 300 men were given employment. Furnace, dressing works, boiler and shaft-houses, offices and other buildings were erected, and large sums of money must have been spent. The extent of the developments is shown on the map and cross-section on the opposite page, reproduced from surveys made by students of Washington University, under the direction of Prof. W. B. Potter. This condition was maintained for a few years, when work was suspended, and the company seems to have collapsed. Everything is in ruin at the mine at present.

The deposit consists of a true vein traversing the granite in a direction somewhat S. of W., dipping from 45 to 60° to the S. The gangue is principally quartz, the metalliferous mineral argentiferous galena, though with this are associated iron and copper pyrite, and, as identified by Haworth [98, p. 20], fluorite, lepidolite, wolframite, and probably other minerals. In the wall-rock, which is considerably altered at the contact, he recognized mica, leucoxene, small zircon crystals, and varying proportions of fluorite and topaz. The contents of the vein do not appear, so far as one can judge from the dump-piles, to have been arranged in layers, but were disseminated through the gangue. The thickness appears to have varied from 2 to 6 feet. The silver contents of the galena was doubtless in many cases high. The results of 58 assays show a range of from 1 to 148 ozs. to the ton; the average of 50 assays was 46 ozs. to the ton. A prospectus of the company states that, from 47 tons of the ore shipped, there was a yield of 2903 ozs. of silver. Some selected samples of ore ranged up to several hundred ounces of silver to the ton.

The country rock, as already stated, is granite, and this is of the common pink and highly feldspathic variety. This is traversed by vertical dikes of diabase running generally somewhat E. of N. These are shown on the accompanying map. One of them is as much as 6 ft. thick. Joint-planes traverse the rock in various directions, breaking it up into prismatic blocks. One prominent system runs vertically in a N.-S. direction. Prof. Haworth reports that a number of smaller, but exactly similar veins are found on the west side of the river.

The Aubuchon Mine.—In section 1, township 32 N., 5 E., in a mountain ravine, about a mile south of Cedar creek, considerable work was done a few years ago upon what was thought to be a quartz vein. The country rock is here a dark, dense porphyry, and this is traversed by short veins or seams of quartz a few inches in diameter, running in various directions and grading into the country rock. No one prominent vein is recognizable, but there is a ramification of quartzose seams. No metalliferous minerals were seen by the writer in the exposed face at the time of inspection in October, 1893. Specimens of galena creditably reported to have come from here have, however, been seen by him. The deposit does not warrant further development.

While speaking of these occurrences in southeastern Missouri, it is worth while to make passing reference to what is called Tin mountain, in section 30, township 33 N., 6 E. There crops out here a great dike or boss of diabase, which some 20 years ago was extensively exploited with the idea that it contained tin. Under the guidance of ignorance or rascality, people were led to invest large sums of money in the venture, from which there was no return. Over \$100,000 were expended here. Of the existence of tin in this or other similar rocks in this state there is absolutely no evidence.

CHAPTER XVI.

THE MINES OF THE CENTRAL DISTRICT.

The Central district, as here defined, includes Cole, Miller, Moniteau, Morgan, Camden, Hickory, Benton and portions of adjacent counties. The exact limits are shown on the map. Beyond these limits there are a few outlying, isolated deposits in Cooper and Saline counties which will receive notice here.

No division of this district into sub-districts will be attempted. The deposits are similar in form and contents throughout, and are, moreover, so scattered and distributed that a simple description by counties is all-sufficient here.

The geological formations within the district are principally of the Lower Silurian, though patches of Lower Carboniferous rocks extend into it along the western and northern borders. Their distribution is shown on the map. In addition, outliers or small patches of Coal Measure shales and coals are numerous, especially over the western and northern parts, but are too diminutive to admit of representation on the map.

The Lower Silurian beds consist principally of magnesian limestones of varying character, mostly associated with chert in nodules, lenses or separate beds; between these, strata of sandstone are recognized at several horizons. The character and distribution of these rocks has been so fully considered in preceding chapters, that further description here is deemed unnecessary. The normal position of these rocks is horizontal, though, in a general way, they have a slight tilt to the north or northwest. Locally, however, much disturbance is noticeable in the shape of sharp and strong flexures. These have already been located and considered, and need not be further noticed here. The statistics of production of all of the counties of the district are given in chapter XIII.

COLE COUNTY.

As has already been stated, lead mining in Cole county has been in progress about 70 years. The period of greatest activity was between the years 1870 and 1876; before and since that time, work has proceeded in a very desultory way. During recent years very few deposits have been accessible for examination, and, though several trips have been made through the county, comparatively little that is new has been gathered to supplement previous descriptions. During the year 1873 and 1874, however, quite full examinations were conducted under Dr. Schmidt, so that our knowledge of the deposits is reasonably complete. The principal of these we will now briefly describe, grouping them about certain centers.

HICKORY HILL AND VICINITY.

East and south of this place are a number of diggings which have yielded considerable ore in the past, and have been worked during recent years.

The Farmer diggings.—These are located about a mile and a half southeast of Hickory Hill, on the north side of Bola creek valley. Work was in progress when the locality was visited by Mr.

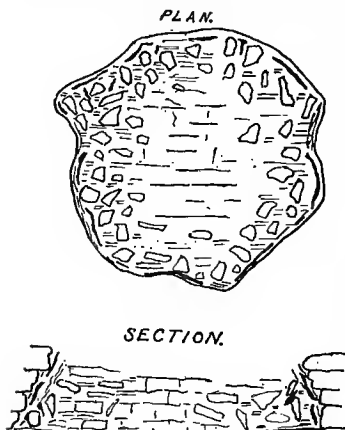


FIG. 253. Ideal plan and cross section of deposit at Farmer mine.

recently opened and produced several tons of galena. Specimens of blende were also found.

Robertson in 1891. The galena was found in masses varying in size from small crystals and fragments less than an inch in diameter, to masses weighing upward of 200 lbs. These occur in residuary clay which is from 10 to 20 ft. thick. About 40 tons of ore had been raised at that time. The shafts are generally not over 20 ft. deep, though one of 50 ft. had been sunk.

From a description given the writer by the operator, it appears that this deposit is one of the so called "circle" diggings, which are of quite frequent occurrence in this district. The open ground or clayey breccia in which the ore is found, is shown by the diggings to be surrounded by a wall of limestone, approximately of the shape represented in figure 253. Sheets of galena are said to have lain close to the wall, with a clayey selvage between; the marginal zone of the circle contained most galena, bedded in clay between blocks of limestone and chert; in the center, the limestone blocks were more abundant and there was little or no ore.

Close to these are the Dooley diggings, which were recently opened and produced several tons of galena. Specimens of blende were also found.

The Henly bank.—This is one of a number of pits in this neighborhood which are worked for barite, the amount of galena present being comparatively insignificant. It is about a mile east of Hickory Hill, in section 11. When visited, in April, 1893, there was a large open cut in the side of a hill in decomposed magnesian limestone and residuary dolomitic and quartzose sands and clayey



FIG. 254. Lenticular masses of barite in decomposed limestone, at Henly bank. Scale 2 ft. = 1 in.

shales; these were seen to be traversed by sheets and short gash veins of barite, generally immediately surrounded by a red tallow clay, though sometimes this was absent. These sheets lay more frequently parallel to the stratification, but they were also inclined at all angles, forming often a perfect net-work in the walls of the cut, somewhat as is shown in figure 254. Some galena is found in the barite. At the bottom of the pit is solid limestone.

Other similar deposits of barite are reported in this neighborhood, and also in the adjoining county of Miller.

The McMillan shaft—This is in section 35, township 42 N., 13 W., not much over a mile from the Osage river. A shaft 47 ft. deep and several pits had been sunk here at the time of inspection. The ore is said to occur in a crevice, in magnesian limestone, running in an E.-W. direction. Layers of chert extend across this crevice unbroken, showing that no faulting has taken place. It is in places 3 to 4 ft. wide, and contains galena, barite and some little blende.

The Fowler mine, described by Broadhead in 1874, was in this same section. The ore occurred in drab magnesian limestone, along cracks and openings which were almost vertical, though irreg-

ular in their courses. In these openings, galena, blende and barite were found, the latter compact and white or in blue and amber-colored crystals. Considerable calamine was also encountered here.

About three miles south of Hickory Hill a group of mines were worked in past years, and exhibited features of special interest.

The Smith or Old Circle diggings.—In the SE. $\frac{1}{4}$ of section 28. Schmidt described this as a true circular deposit, 120 ft in diameter, but increasing in width with depth; only about 15 ft. of the marginal portion was rich enough to work, and the galena became exhausted downward. Broadhead described the ore as occurring in clay and sand, and in fissures in limestone, associated with barite, galena, iron and copper pyrite and calcite.

The Central diggings —These were in section 21, about a mile north of the last. Here, according to Schmidt, the galena occurred in clay along cracks in the limestone. One of these cracks led to a small cave filled with red clay, ocher, chert, pyrite and galena. Near the summit of the hill, a shaft followed a chimney or vertical cavity filled with clay and loose galena. At other points in this and the adjoining section, small quantities of galena had been obtained from the surface clay and from crevices in the rock.

RUSSELLVILLE AND VICINITY.

In the township south of Russellville, along the south fork of Moreau creek, much mining has been done.

The Eureka-Scott diggings.—These were located in the SE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 23, township 48 N., 14 W. The deposit is described by Schmidt as circular in form, about 110 ft. in diameter at the surface, and 130 ft. at a depth of 65 ft. It is illustrated in the adjoining figure. This was surrounded by softened limestone, of which the strata were seen to dip slightly to the north. Evidence of stratification was discernible in the least disturbed portions of the deposit. The wall rock had, at times, seams of galena adhering to it, and such also extended between the strata. Within this wall the ground was very much broken and altered, especially close to the wall, where also the largest masses of galena were found, in broken veins and pockets, associated with barite. The richest portion of this marginal zone was on the southern side, where it was 15 ft. wide; on the northern side the width was only 5 ft. The more central portion of the deposit consisted of large, broken blocks of limestone traversed by thin seams of galena. Below the depth of 65 ft. explorations showed that the rocks became harder and less altered, and contained less galena. Barite was abundant in the ore bearing portions, in thick, broken veins 6 to 8 in. thick. The seams of galena were from 4 to 5 in. thick. Some blende was also found. The mine was first opened in 1871, and by 1874 had produced about 1000 tons of galena.

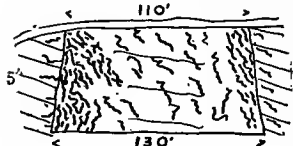


FIG. 253. Section Eureka-Scott deposit.

Within this wall the ground was very much broken and altered, especially close to the wall, where also the largest masses of galena were found, in broken veins and pockets, associated with barite. The richest portion of this marginal zone was on the southern side, where it was 15 ft. wide; on the northern side the width was only 5 ft. The more central portion of the deposit consisted of large, broken blocks of limestone traversed by thin seams of galena. Below the depth of 65 ft. explorations showed that the rocks became harder and less altered, and contained less galena. Barite was abundant in the ore bearing portions, in thick, broken veins 6 to 8 in. thick. The seams of galena were from 4 to 5 in. thick. Some blende was also found. The mine was first opened in 1871, and by 1874 had produced about 1000 tons of galena.

The Entoe diggings —These, in the NE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 15, were about a mile northwest of the last. Here, shafts 20 or 30 feet deep had been sunk, following a course about NE.-SW. Galena and barite were found in clay openings 3 to 4 feet wide, enclosed in limestone. A lower 3-foot opening, 22 feet deep, was filled with partially bituminous clay. No ore was found at this lower level, though galena occurred in specks in the limestone immediately above.

Doogan diggings.—In the SE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of the same section were the Doogan diggings on the old Chouteau lands. Here a run of loose galena in red and yellow surface clay was worked. It was also found in cavities in the soft limestone.

Henderson diggings.—In these diggings, in the SE. $\frac{1}{4}$ of section 14, adjoining, galena was found in the clay associated with chert, and also in seams and softened limestone. No barite was with it, but some calcite occurred. The galena was confined to an elliptical area of about 80 by 40 feet, the axis running SW.-NE. Other similar deposits and small openings occurred immediately about here.

The Booz diggings.—These were about a mile south of Russellville, in the SW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 2. According to Schmidt's descriptions, this was also a circle deposit, about 150 feet in diameter. The galena was found loose in the red clay, sometimes in large masses, the richest portion of the deposit being confined, as usual, to an annular space along the outer margin, from 25 to 30 feet wide. At depths, the limestone was found to become harder and less altered, and the seams of galena diminished in size and in number. The deposit grew wider with depth, developing the shape of a truncated cone. Some barite was found here and some cerussite.

The Rapp diggings.—These were about six miles east of Russellville and a mile south of Stringtown, in the NW $\frac{1}{4}$ of section 3, township 43 N., 13 W. Galena was found loose on the surface, and also in red clay associated with broken sandstone and chert. Below this, thick seams of galena were found between broken masses of limestone.

ELSTON AND VICINITY.

In the country south of Elston, small quantities of lead ore have been mined during the past 25 years, and north of this place, not far from the Missouri river, deposits have been worked.

Caspary mine.—An opening has recently been made here about 2 miles south of Elston, near the middle of section 2, township 44 N., 13 W. At the time visited, in November, 1893, a shaft about 25 ft. deep had been sunk on a spur of the hill. It passed through blocks of magnesian limestone, between which the galena was found in clay cavities, well crystallized. No crevice was discovered. Galena was dug from shallow pits all about the shaft within a radius of 50 ft. or more. Over this area the soil was noticeably of a dark color. In a pit about 100 ft. south, the limestone was seen to dip as much as 30° N. Across the hollow to the north, about a quarter of a mile, a number of coal pockets have been operated. In these Broadhead observed blende traversing the coal in small seams.

The Elston mine.—The Elston mine has been described by Broadhead as on the south side of Gray's creek, about a quarter of a mile from the station. The ore was found in an opening in the magnesian limestone more than 2 ft. square. This opening followed a sinuous course, varying from a southward to an eastward direction. It was filled with soft limestone containing galena, which latter occurred in sheets about a foot wide and averaging about 3 inches thick, sometimes much thicker, though thinning out entirely in places. Occasional chimneys were found penetrating the overlying rocks. Six tons of galena were obtained from this mine.

In close proximity to these, other openings have been made from which small quantities of ore have been obtained. The deposits are all essentially of the same character. Three miles south of Elston were the Lamlein & Staehlin diggings, where ore was found in clay and in thin veins in magnesian limestone.

North of Elston, along the Missouri river, were also a number of openings. At the *Dobson mine*, in the NE. $\frac{1}{4}$ of section 15, township 45 N. 13 W., galena was found in clay on the river bluffs. At the Dunlap diggings, in section 5 of the same township, galena occurred in cavities in limestone.

CENTERTOWN AND VICINITY.

About Centertown are also a large number of mines, none of which, however, have been of special importance.

Streit's mine.—This was in the NE. $\frac{1}{4}$ of section 2, township 44 N. 14 W. A shaft was sunk in magnesian limestone, in which galena was found in crevices, enclosed in barite; a little blende and calamine were also found. Blende occurs in the coal of different coal pockets in this vicinity. Several shafts have been sunk immediately about this one.

The Weaver diggings.—In section 25, township 45 N. 14 W., less than a mile north of Centertown, vertical crevices were found 2 to 3 ft. wide, in limestone. These were filled with clay, broken chert and some galena. Near by, specks and seams of barite were seen traversing the limestone.

MILLER COUNTY.

Little mining was done in Miller county before the year 1870, though some little prospecting is recorded. With the high prices that prevailed between the

years 1870 and 1878 mining became comparatively active, however, and some 2000 tons of ore were produced. Since then little or no work has been done, and opportunities for observation have been very scarce during recent years. The principal mining to date has been along Saline creek and its forks, within township 41 N., 14 W.

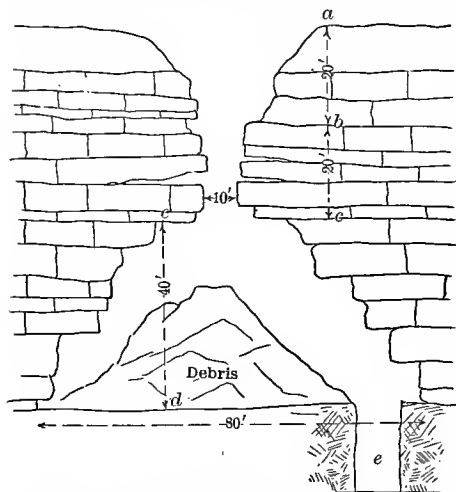


FIG. 256. Section of the circular deposit at the Conlogue mine.

Chief interest attaches itself to the large open pit or conical chimney at the Pioneer shaft. This is illustrated and described in accompanying figure (256), made from measurements of the

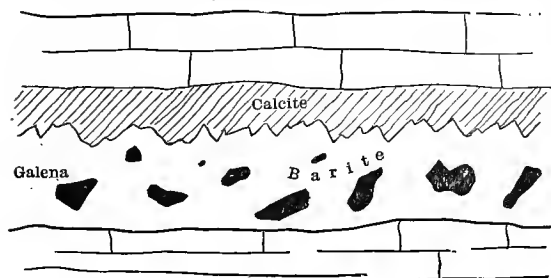


FIG. 257. Cavity fillings at the Conlogue mine.

as shown in figure 257. Much of the barite occurs in crystalline masses, clear and glossy, like calcite, with rhombohedral cleavage and apparently pseudomorphous after the latter mineral.

This deposit was examined by the Geological Survey in 1873, when it was being worked, and is described by Schmidt as of circular shape, 30 to 40 feet in diameter and increasing in width with depth. The upper part was filled with red tallow clay; the lower part with masses of broken limestone, altered and softened, though angular, with broken sheets of galena and barite between. Seams of galena extended into the wall-rock in places and such were followed as much as 40 feet. Such seams also extended below the bottom of the shaft, but the enclosing rock became harder. Copper pyrite and malachite were found with the barite. Galena was always deposited on the limestone while the barite filled the remaining space, sometimes in fine crystals. The whole mixture

The Conlogue mine.—This mine is situated in Miller county. Though the yield has not been very large, it is an excellent example of the so-called "circle" deposits of the Central district. It is situated in the NW. $\frac{1}{4}$ of section 5, township 41 N., 14 W. More work has been done here, and greater quantities of ore obtained, than at any other mine in Miller county. A large amount of shallow surface ore was found, as is attested by the innumerable pits which cover the hill-sides.

writer's. The galena, as seen in undisturbed pillars, is firmly imbedded in calcite or barite lining cavities; in the breccia, however, it is said to have been loose, and the whole mass was excavated with pick and shovel. Sheets of barite were seen attached to the wall of the chamber, and galena is said to have been found in similar sheets, both attached to the surfaces and penetrating crevices in the wall and floor. The minerals filling the cavities are disposed somewhat as is

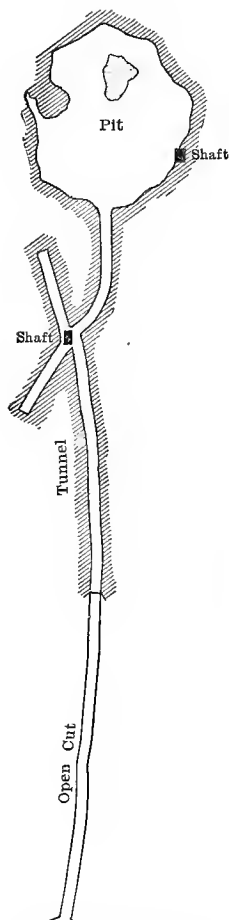


FIG. 258. Open cut and tunnel of Conlogue mine.

contained from 5 to 10 per cent of galena. About 500 tons were estimated to have been mined here up to May, 1874.

Recently, a tunnel has been driven into the hill-side through the magnesian limestone country rock to the circle or central pit, with the idea of draining the latter and of reaching a large body of ore which was commonly believed to still remain. A plan of this tunnel is shown in figure 258. It followed an ill defined vertical crevice, with lens like expansions, containing galena and barite. These lenses were, in cross-section, a foot or so long and about 6 inches wide; they were also found between the horizontal beds of the wall-rock. Their arrangement is illustrated by figure 259, from an actual sketch of a face in the tunnel.

No faulting movement has taken place along the vertical crevice. The galena was also found in thin sheets. In all such cases, however, it is in the solid undecomposed rock, with no clay, though barite and calcite generally accompany it. The magnesian limestone is of course, open texture. Chert is imbedded, in nodules and lenticular layers.

Northeast of Pleasant Mount, Meek refers to the *Greenup mines*, in section 20, township 40 N., 14 W. Here a 3-ft. fissure, running N.-S.,

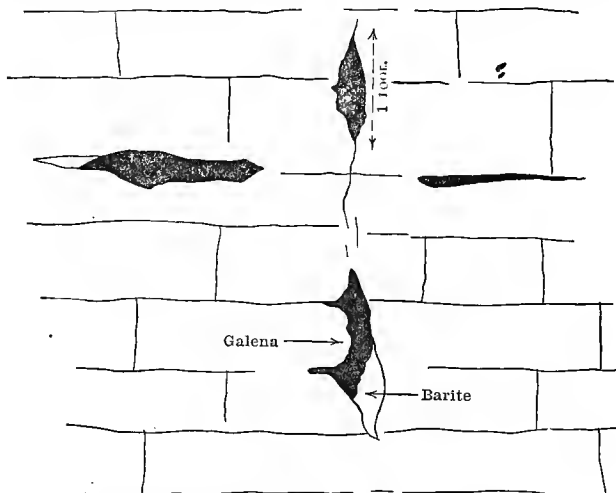


FIG. 259. Ore lenses in magnesian limestone at the Conlogue mine.

was encountered filled with galena and clay. In section 25 of the same township, he describes another fissure or crevice 8 to 18 inches thick, running E.-W.; this was found filled with barite and occasional crystals of galena; it was struck at two points 300 ft. apart.

The Hoff diggings.—These were in the NE $\frac{1}{4}$ of the NE $\frac{1}{4}$ of section 6, township 41 N., 13 W. They were described by Schmidt in 1874. Galena was found loose here at the surface and also in crevices running SW.-NE., which connected with numerous chimneys and crevices. These contained galena in red and yellow clays. The enclosing limestone was fine-grained and somewhat altered and soft. No barite was found, though some calcite was associated with the galena. A parallel crevice was also discovered here and another at right angles to this.

The McMillan diggings.—Here, in section 35, township 42 N., 14 W., galena was found in clay and in cavities in the limestone at depths of from 10 to 25 ft. In places, thin seams of galena associated with barite were found in the limestone. Immediately south of this, in section 2 of the adjoining township, Meek observed occasional crystals of galena disseminated in the limestone.

The Blackburn diggings.—These were in section 10, township 41 N., 14 W., less than a mile southwest of the last. Schmidt describes the galena as found in red clay and in long subterranean channels.

The Hackney diggings, immediately south, in the SW. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 14, was the site of numerous shafts from 10 to 50 ft. deep. The ore occurred in tallow-like clay, containing much broken chert, and was also found in broken alaba between blocks of soft magnesian limestone.

The Grass Root diggings.—These were in sections 23 and 26 of the same township. Numerous shafts were sunk here, and the galena was obtained from the residuary clay between depths of 10 and 20 ft. One shaft was sunk 80 ft. deep, and penetrated solid limestone 55 ft. Although some small veins and cravices filled with galena were encountered, they grew smaller with depth, and further exploration was abandoned. About 250 tons of ore were mined here.

Melton diggings (R).—These are about four miles northeast of Tusculum, and were operated by L. E. Melton & Company.

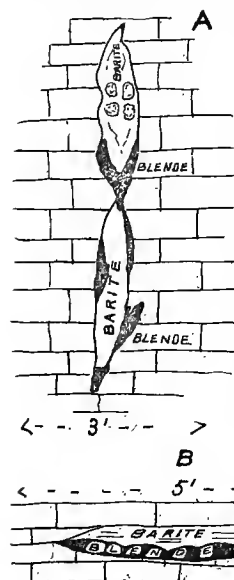
In the superficial materials from the surface of the ground to that of the limestone, the galena was found in masses varying from fragments of the size of a pea to pieces weighing 500 lbs. There were some 12 to 15 shafts sunk, and about 25 tons of galena had been raised since the deposit was opened in October, 1891.

About one mile west of Aurora Springs, Mr. P. J. Davidson has mined for lead. It occurred as above, in the surface clay.

The Capp diggings.—These were in the NW. $\frac{1}{4}$ of section 12, township 40 N., 13 W. Galena was found loose in the clay and extending into horizontal and vertical cavities in the limestone. Thin sheets and seams of galena in hard limestone were also met with. Some calcite, but no barite, occurred here.

In the southwestern corner of Miller county, near Tavern postoffice, more or less prospecting has been done during the past 40 years. Some recent developments were examined by the writer in November, 1893, with the following results:

Rothwell or Crisman diggings.—These are in lot 5 of the N. E. $\frac{1}{4}$ of section 2, township 39 N., 12 W. Several pits were opened along and adjacent to Rothwell branch. The adjoining sketches



illustrate the conditions of occurrence. The vertical gash vein, illustrated in A, is traceable in a sinuous line across the bottom of the pit and up its two sides, a horizontal distance of about 4 ft. It pinches out at the top, as is shown in the sketch. In a flat opening on the western side, a little above the vertical deposit, a mass of galena and barite about a foot in diameter was found. Some galena occurred mixed with the blende in several openings, and also some copper pyrite and smithsonite. The surface of the magnesian limestone at the contact with the ore is generally stained a red color.

Other similar occurrences were exposed in different pits, and, in some, large quantities of tallow clay were associated with the ore. Barite is frequently found in this vicinity in isolated nodules in limestone, and also over the bottom of small cavities, with blende between it and the rock; the barite seems thus to have been deposited after the blende. Cravices frequently traverse the limestone, expanding at intervals, forming lenticular cave-like openings. One was seen crossing the bed of the creek, running SW—NE. and containing galena and blende. No faulting had occurred along it.

A number of other openings of minor importance have been made elsewhere in Miller county, but special descriptions of such have not been obtainable. The above will, however, give a fair idea of the general distribution and character of the deposits of the county.

FIG. 260. Sections of gash veins at Crisman diggings.

MONITEAU COUNTY.

Little or no lead mining has been done during recent years in Moniteau county. The most remarkable deposit operated in past years was the High Point mine, near the postoffice by that name.

High Point mine.—This mine is located in the NE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 17, township 43 N., 15 W. Work has not been done here for many years, and on a recent visit to the locality by the writer, the excavation was filled with water. The deposit was discovered in 1841, and by 1845

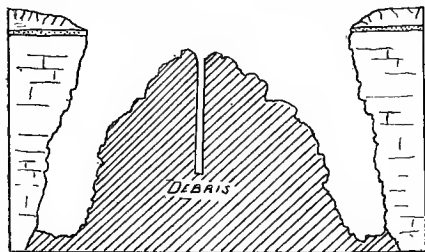


FIG. 261. Cross-section of High Point mine.
From Meek, report 1854.

had produced 1000 tons of ore. It was reopened in 1854, and was at that time visited by Prof. Meek. The adjoining figure is copied from an illustration given in his report. He described it as a circular pit, 100 ft. in diameter and about 80 ft. deep, widening downward. A cone of broken rock occupied the center, and around this an annular space was worked out. This latter was filled with broken blocks of limestone of different kinds, irregularly mixed, between which there was finer material of the same kind. In this comminuted rock much galena was found, but the larger masses were in cavities, principally filled with red clay. Most of the ore was found in the softer portions, and principally close to the surrounding wall. The central mass was of the same structure, but contained much less galena. The galena was very pure, and with it some little blende was found. Calcite occurred in small quantities, and Schmidt noticed a little barite in the debris in 1874. The wall rocks were composed of a thin cap of sandstone, succeeded by a thinly-bedded, gray cotton rock, and this followed lower down by a somewhat open-textured magnesian limestone. These rocks were comparatively undisturbed and exhibited no dip, though they were fractured and traversed by joint-planes.

The depth of the body was undetermined at the time. Schmidt notes that in 1857 a depth of 90 ft. had been reached, and that galena was still in sight, though the ore body was less rich than at higher levels. From the presence of vertical slickensided stræ, Meek concluded that the brecciated condition of the rocks was due to a "powerful elevating force acting from beneath." He was unable to indicate the source of the ore, however, and saw no evidence of igneous action. This is one of the largest of the peculiar circular deposits of this district, and its formation is to be explained in the manner described on page 467 of this report.

Kellog diggings.—These were about three miles north of High Point, in section 33 of the next township. Meek described the galena as occurring in a crevice in magnesian limestone, 2 ins. wide, running E.-W. Other seams were seen crossing this at right angles. Galena is also found loose in the surface clay.

Hart diggings.—These were about five miles northwest of High Point, in section 3, township 43 N. 16 W. Three shallow shafts had been sunk through about 4 ft. of surface clay, in the soft, yellow magnesian limestone. In the latter, galena was found in bunches or in isolated crystals, associated with calcite. In one pit a crevice 18 ins. wide, filled with red clay and loose galena, was found. A porous magnesian limestone was beneath this, containing no ore.

The Eames diggings.—These were about 8 miles northeast of High Point, in the W. $\frac{1}{2}$ of section 32, township 44 N., 14 W. Float galena was found in the red clay and also in seams and pockets in the limestone, with a little barite.

Mineral Point diggings.—These were new developments in 1873, located in the NE. $\frac{1}{4}$ of section 10, township 45 N., 15 W. Schmidt describes the galena as occurring in veins in magnesian limestone $\frac{1}{4}$ to $2\frac{1}{2}$ ins. thick, with a N.-S. course. It had been traced 750 ft. up the slope. Another similar vein was found running parallel to the first and about 75 ft. east of it. Masses or slabs of galena were found in the surface clays also.

Reed diggings.—These were in the NE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 12 of the same township. A shaft 120 ft. deep penetrated broken, soft magnesian limestone, containing large pockets of galena, and also pockets filled with barite and clay. In the lower 30 ft. only traces of galena were found.

John English's pit.—As described by Meek, this was in this same section, on a fork of Lower Brush creek. A shaft 12 ft. deep exposed a crevice about 2 ins. wide, filled entirely with galena, running N.-S.

The Tiff diggings.—These were about two miles northeast of the last, in the NE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 35, township 46 N., 15 W. Schmidt described an open, quarried face, 50 ft. wide and 24 ft. high, exposing great blocks and broken veins of white barite, between softened limestone. Galena was found only in small quantities. This deposit was evidently very similar to the Henley diggings of Cole county, already described.

At the Dickson mine, in section 25 of the same township, float galena was mined in earlier years from shallow pits.

English, Sartin and Wells diggings.—These were described by Meek. They were in section 17, township 45 N., 14 W., near the summit of the ridge. Ten or more shafts had been sunk to depths of between 30 and 60 ft. Galena was found in the surface clay with fragments of chert, and also in magnesian limestone, in isolated masses in cavities, and in flat sheets along joint-planes. In these it was often associated with red clay, and sometimes with barite.

English and Powell diggings.—These were in section 5 of the same township. They consisted in 1854 of four or five shafts down to depths of 30 ft. In one of these a crevice was encountered, from 3 to 6 ins. wide, running NE.-SW. Galena was found in this and also in surface clays.

Near the western limits of Moniteau county, on the Newkirk land, in section 12, township 44 N., 17 W., galena was found in small cavities, and also filling seams and joints of the magnesian limestone, $\frac{1}{4}$ to $\frac{1}{2}$ in. wide. No parallelism of these veins was noticed. In sections 24 and 25 of the same township, galena was also found loose in surface clays.

In the extreme northern portion of the county, in township 47 N., 15 W., lead ore has been mined at several localities. At the Klinger diggings, in the SW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 25, several drifts exposed, in 1873, masses of barite in sandy clay. At Howard's branch, in section 24 of this township, loose galena was found in chert, associated with barite. These last deposits, it will be noticed from the map, are in Lower Carboniferous rocks, whereas all others of Moniteau county are in the Lower Silurian magnesian limestone.

MORGAN COUNTY.

As has already been described, some little mining was done in Morgan county before 1850, and also during the succeeding score of years; but, like all of these central counties, work was not active here until after 1870, when many deposits were opened, and the county production rose in the next decade to about 3000 tons of ore. Since that time mining has been very slack, and only desultory work has been done.

As expressed by Meek in 1855, there is scarcely a township in the county but where lead ore has been found. This has been mostly in loose slabs or fragments in surface clays; but, at many localities, it was also mined from the rock. For convenience of reference, and because of the great number of localities, we will arrange the following descriptions by townships, beginning with the southmost.

TOWNSHIP 40 N., 17 W.

In section 2, north of what is now Gladstone P.O., Meek observed several crevices in magnesian limestone on a summit of a ridge. These varied in width from a few inches to 3 ft., and the principal ones ran NE. to SW. Similar crevices were observed running at right angles to these. They were filled with clay and broken rock, in which galena was found.

Bond diggings.—These were in the SW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 9, and in the SE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 16. Schmidt described them as being principally in surface clays, in which the

galena was found in fragments associated with barite, and sometimes in vertical sheets along parallel lines running NE.-SE., and traced 100 to 300 feet in length. The surface clay was 6 to 8 feet deep, and from this the seams extended into solid limestone. Blende was rarely found. Calcite and barite were sometimes associated with the galena.

Johnson-Davidson diggings.—In the northern part of section 26 were the Johnson-Davidson diggings. The galena was found mostly between depths of 6 and 10 feet, in layers in the clay. One shaft 40 feet deep extended 30 feet into the limestone, in which cavities and fissures were encountered containing sheets of galena, associated with calcite in places.

The Brush Creek or Ely diggings were in this and the adjoining section 27. Elsewhere in the township, lead ore has been mined in small quantities at a number of points.

TOWNSHIP 41 N., 16 W.

In section 4 Meek noted the presence of crevices, 6 to 15 inches wide, traversing fractured strata and containing broken chert and galena; polished surfaces of rock fragments indicate movement here. In section 5, in the SE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$, were the Kelsey diggings, where galena was found in seams in the limestone without barite.

The Madole diggings.—These were in the SW. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 8. Here a cave was encountered in a shaft at a depth of 40 ft., after passing through clay and blocks of chert and limestone. This cave extended eastward from the shaft a distance of about 150 ft., and was crossed near the shaft by an opening in the rock, running nearly at right angles with the cave, filled with clay and galena. Shafts were also sunk along two depressions called breaks, which ran along the hill-side from SE.-NW. nearly 800 ft. In these, galena was found loose in the clay and between blocks of chert and softened limestone. In the immediate vicinity of these, along Indian creek, a number of other mines were worked.

In section 18, Meek reported the discovery of a vein traversing magnesian limestone on T. V. Jones' land. This was filled with clay, limestone, sandstone and galena, and sometimes a little barite. The course was E. of S., and the vein had been traced nearly a half mile. This width varied from $\frac{1}{2}$ to 18 inches, though cavities 3 to 4 ft. across were encountered.

The Dolph diggings—These were near the middle of section 18. Here Schmidt described crevices running NW.-SE. filled with galena and barite traceable for a quarter of a mile, and followed to a depth of 70 ft. The thickness remained constant, though varying from 3 to 12 inches. Softened fragments of limestone were encountered in the barite.

In sections 4 and 7, occurrences of lead ore and zinc ore have been noted, but no developments are yet made.

TOWNSHIP 41 N., 17 W.

In section 17 of this township, loose galena was found in the clay as early as Meek's report. Later, the O' Bryan diggings were in the same section. In sections 18 and 24, occurrences of ore and barite have also been noted. In the NE. $\frac{1}{4}$ of section 24 were what were known as the *Lower Indian Creek diggings*, in which loose galena was found in a bed of red clay overlying decomposed limestone; also in irregular openings of the rock.

TOWNSHIP 41 N., 18 W.

The Brushy diggings.—These were in section 12, and, as described by Schmidt, galena occurred loose in the red clay, following along a run in a NE.-SW. course, between depths of 20 and 40 ft. The ground consisted of broken masses of limestone and chert, under which rounded pieces of barite and galena were found. In the *Gray Horse diggings*, in the NE. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 13, ore was found under similar conditions.

The Caldwell diggings.—In the NE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 14, a shaft nearly 100 ft. was sunk, passing through 40 ft. of clay with barite and galena, and through more than 55 ft. of large sandy blocks of limestone, with white, dense barite and some galena.

In sections 18, 24, 29, and at other localities in the township, lead ore has been dug under conditions similar to those described.

TOWNSHIP 41 N., 19 W.

The Buffalo diggings.—These were in the SE. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 1. Schmidt described two shafts 31 ft. deep, which encountered a rich deposit of galena. The ore-body consisted of broken limestone, between which was sand containing galena in irregular masses and seams. It had a somewhat circular outline, and was about 30 ft. in diameter, but extended beyond these limits in places. A large shaft, 16 ft. wide, had been sunk to a depth of 50 ft., at which depth the proportion of galena diminished. The deposit was worked later by an open cut. A good deal of work was done here, and furnaces were erected, which smelted the ores from this and adjoining mines.

The Johnson diggings were in the same section, about 700 ft. southeast of the last. Shafts 25 ft. deep were sunk through clay into disintegrated limestone.

At the Wilson diggings, in the SE. $\frac{1}{4}$ of section 12, seams of galena were found running through chert and limestone.

TOWNSHIP 42 N., 16 W.

The Strong diggings were in the NW. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 27. Here galena was obtained from the surface clay.

At the Toke and Skelton diggings, in the same section, Meek described detached crystals of galena and numerous seams of galena, $\frac{1}{2}$ and $\frac{3}{4}$ of an inch thick, running in every direction, both horizontally and vertically, in broken limestone. Over this was a light, flesh-colored limestone, destitute of ore.

TOWNSHIP 42 N., 17 W.

This township has been, perhaps, the scene of more mining than any other in the county.

The African diggings were in the NE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 5. Schmidt described these as shallow pits arranged in a somewhat N.-S. course. The ore was found mixed with clay, shale, sand and soft limestone, and also in red surface clays.

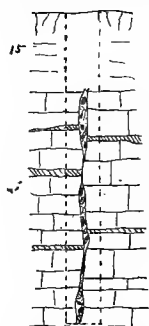


FIG. 262 Section of McCormick shaft.

The McCormick and Thayer shaft.—This was in section 8, and was examined by the writer in 1890. It was sunk on a thin lode to a depth of 85 ft. The adjoining sketch illustrates what was observed here. The crevice was from 0 to 4 ft. wide, and was filled with a breccia, consisting of chert and sandstone fragments in a sandy matrix. Through this the galena was disseminated. The wall rock consisted of magnesian limestone, with layers of chert, which were not continuous from one side of the crevice to the other, showing a vertical movement. About 5000 lbs. of galena had been taken out from 25 ft. of the crevice. As the shaft was about 5 ft. wide and the thickness of the lode averaged about 2 ft., the excavation was about 250 cubic ft., and the yield amounted thus to 20 lbs. of galena to the cubic foot of vein material.

Cross-roads diggings and others.—In this same section were the Ross pits, referred to by Meek, from which large blocks of massive galena, weighing 50 lbs. or more, were taken. The well-known Cross roads diggings were also in this section and in the adjoining section 9. The last were also known as the *New Granby diggings* in 1874, under which are included by Schmidt the Woods, Huff, Cross-roads and Wilkinson. Most of the ore was found in the clay, though some was between blocks of limestone, and also in specks and thin sheets in the solid rock. The ground was very much disturbed, and some of the diggings were arranged in an approximately circular shape, suggesting a circular form of the deposit. The rich ground was sharply limited, and a solid limestone bar was encountered northeast of the pits. Quite large quantities of ore were obtained from these mines. Furnaces were also erected here.

In section 16, the Silvey Zinc mines were opened in 1887, small quantities of blende being found.

The Townley and Gunn diggings were in the NW. $\frac{1}{4}$ of section 23. Shallow shafts were sunk, in which galena was found in clay and in seams in the limestone. Much broken chert was encountered in the clay.

The Wyant Spring diggings.—These were in the SE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 32. Schmidt described a long row of shallow shafts running NNW.—SSE. for a distance of about 1000 ft. These

were sunk to depths of 10 and 20 ft., in red and yellow clays, containing loose galena. At one shaft near the mill, a crevice was struck in the solid limestone, varying from 6 to 30 ins. in width, and with a strike parallel to that of the row of shafts. This was filled with black clay, crushed shale and chert, and also blocks of softened limestone. Galena was found adhering to the wall rock and to the enclosed blocks. A shaft was sunk 55 ft. on this crevice. Another shaft struck a parallel crevice, about 35 ft. away, which was from 1 to 3 ft. wide, and was filled like the other. Shafts above this, on the hill-side, disclosed little or no clay, though some galena was found in thin sheets in the limestone.

In section 33, and at other points in this township, small quantities of galena have been found, but little digging has been undertaken.

TOWNSHIP 42 N., 18 W.

In section 18 were the Argenbright and Fair diggings, from which a number of tons of galena have been obtained.

The *Simmons diggings* were in the SE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 20. The deposit occurred in caves and cavities in the limestone, and consisted of red clay and loose galena.

Huffman mine—In section 21, a good deal of mining was done in past years, and recent developments have also been made here. The Huffman mine was in the NW. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 21, and were visited by the writer in 1890. A shaft had then been sunk to a depth of about 70 ft., principally in magnesian limestone. The galena was seen in crystals, scattered through the rock, and no concentration of the ore was observed.

Big Three shaft and Old Clark diggings.—The Big Three shaft was a little south of the Huffman mine, in the SW. $\frac{1}{4}$ of the SE. $\frac{1}{4}$. This is close to the site of the Old Clark diggings, worked in 1878, where some 250 tons of galena were taken out of the superficial clays. A shaft about 20 ft. deep encountered a nearly horizontal run of ore, consisting principally of blende associated with barite. Little or no lead ore was obtained. When visited later by Mr. Robertson, a drift had been carried 300 ft. along the course of the "run," which was a mineralized portion of the dolomitic limestone, having a general course N. 60 W. The ore was wholly zinc blende, occurring generally in barite, sometimes in crystalline forms and sometimes in irregularly shaped masses. No ore had been shipped from these workings.

The *Old Clark diggings* were in the SE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 20. Schmidt described the deposit as consisting of numerous seams of galena, blende and barite $\frac{1}{4}$ to 3 inches thick running through limestone. The main seams ran E.-W. and were connected by cross seams. This network was exposed over an area of 50x30 ft., but thin seams were found elsewhere also. Very many diggings have been worked here, and much galena was found in the surface clay.

The Potter No. 1 mine—This was in the NW. $\frac{1}{4}$ of the same section 21. Here crevices 1 to 4 ft. in width were traceable in the limestone a distance of 300 ft. in a SW.-NE. direction. These were followed to depths of 80 ft., and were found filled with red clay, broken chert, calcite and large pieces of galena.

In the *Stover diggings*, in the SW. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of the same section, two crevices like the last were found running SW.-NE.

The *Merritt diggings*, in the SW. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 23, developed irregular crevices and cavities in the limestone, containing clay and galena.

The *Ferguson diggings*.—These were in section 23, in the SW. $\frac{1}{4}$. It was in this section that the first mining in the county was done, in 1837. At these diggings a crevice was developed in the limestone 6 to 12 ft. wide, dipping 45 to 60°, as illustrated in the adjoining sketch taken from Schmidt's report. The roof was chert about 1 ft. thick, the foot-wall limestone. This was filled with fragments and blocks of limestone, between which ran a net-work of barite veins up to 3 inches in thickness, enclosing crystals of galena; these were associated with red clay, which also contained crystals and fragments of barite and galena.

The Potter No. 2 mines.—In the NW. $\frac{1}{4}$ of section 31, four shafts were sunk, in clay and conglomerate of broken chert fragments, surrounded by clay and galena.

In the *Wolf Den diggings*, in section 30, immediately north of the last, galena was found both in the surface clay and in seams in the limestone.

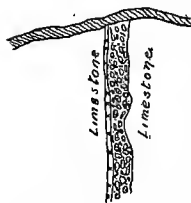


FIG. 263. Section of lode at Ferguson diggings.

TOWNSHIP 42 N., 19 W.

In this township no diggings were recorded, but Meek refers to several seams of galena, about 1 in. in diameter, in section 34. These ran in an E.-W. direction, and were traced about 450 ft.

TOWNSHIP 43 N., 18 W.

In section 10 was what was known long ago as the Wyant, Trigg & Bryan diggings, and later as the Perry Ross diggings. Galena is said to have been disseminated in altered limestone.

The Gabrielle diggings.—These were in the NW. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 17. Galena was obtained from the surface clay, underlying broken and decomposed limestone. The ore was distributed irregularly, though sometimes seemed to follow straight lines or runs. In one shaft, 65 ft. deep, Coal Measure shale, containing much pyrite was encountered, dipping down between broken masses of limestone. Quite large amounts of lead have been produced from these diggings.

TOWNSHIP 43 N., 19 W.

In this township lead ore has been found in the W. $\frac{1}{2}$ of section 5.

TOWNSHIP 44 N., 18 W.

In this township, in section 12, is what was known as the *Bluff Spring zinc mines*, where some developments were made in 1888.

TOWNSHIP 44 N., 19 W.

In section 20 of this township, Meek refers to lead ore on Luckett's land in section 20. In the NW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 25 were the Stocker diggings, where galena and blende were found in black clay, associated with black slate.

The Price Mill diggings—These were in the E. $\frac{1}{2}$ of the SE. $\frac{1}{4}$ of section 35. One large and several small veins of galena and barite were found traversing limestone. The large vein ran NW.-SE., was of variable thickness, but nowhere exceeded 6 inches. The galena adhered to the walls and sometimes filled the vein entirely; but generally a portion of the space was filled with barite. The smaller veins ran nearly at right angles to the other.

The Otten diggings were in section 36, adjoining. These consisted of shallow shafts in which loose galena was obtained, lying between sandy limestone blocks, under the red surface clay. In the limestone bluff adjacent, sheets and specks of galena were seen.

TOWNSHIP 45 N., 18 W.

The Twin Spring diggings were in the SE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of section 19. Schmidt described crevices and cavities in the magnesian limestone running generally from NE.-SW. Galena occurred loose in red clay, and was somewhat rounded; barite was sometimes associated with the galena. In section 35, on Marcus Tapping's land, are also lead diggings.

TOWNSHIP 45 N., 19 W.

The Cordray diggings—These were in the NW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 22, near the Otterville lead furnace. Three shafts were sunk, extending into broken, soft magnesian limestone, mixed with clay, chert and loose galena, the latter frequently adhering to the chert. Some large cavities were encountered, filled with black clay, enclosing crystals of blende. The chert here was of Carboniferous age.

The Weir diggings were in section 34, in the SE. $\frac{1}{4}$. A shaft, 50 ft. deep, penetrated a mixture of limestone fragments, both rounded and sharp, surrounded by red clay, containing loose barite and galena. *The Zollinger diggings*, in the NE. $\frac{1}{4}$ of the same section, encountered galena under similar conditions.

At a number of other points in the county, lead ore has been obtained, but this has been principally from surface clays, and no special descriptions of the deposits are preserved. A large number of coal pockets are encountered, and, associated with these, more or less ore, especially blende, is frequently found. Thus, at the *Martin coal bank*, in section 5, township 42 N., 17 W., blende is found in well-formed crystals, in small pockets distributed through the coal, and also in sheets following the joint-planes. At the *Simpson coal pocket*, just across the county line, in Monticau county (section 15, township 43 N., 16 W.), large slabs of blende, $\frac{1}{2}$ in. or more thick, can be obtained from such joint crevices.

CAMDEN COUNTY.

A little lead mining was done in Camden county as much as 50 years ago, but most of it was between the years 1870 and 1876. The county has, however, never been a very large producer, and so little has been done during recent years that very few opportunities for observation were afforded during the recent trips made to the county. The principal work has been in the vicinity of the town of Linn Creek.

Hunter's diggings.—These were formerly known as the Thomas mines. They are situated in section 21, township 39 N., 16 W. When visited by the writer in November, 1893, no work was in

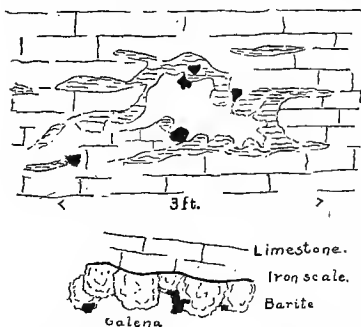


FIG. 264. Barite and galena in magnesian limestone, at Hunter's mine.

progress, but several pits and drifts were open for inspection. The galena was found in the magnesian limestone in irregular pockets, distributed generally along the stratification planes. It was associated with a great deal of barite. The adjoining sketches illustrate exactly the conditions of occurrence of the ore. The barite was partly in peculiar nodules, the surfaces of which were roughened by small crystals of the same substance, stained a red color, causing somewhat the appearance of an Osage orange. Into the rock enclosing the cavities, irregular veinlets of barite often penetrated; in places the adjacent limestone was decomposed to a dolomitic sand. The galena was bright and clean on a fresh surface, and had a sharp contact with the barite. Over exposed surfaces it is oxidized to cerussite. Barite and galena often line the interior of the cavities, but as a rule do not fill them completely. The barite is generally compact and chalky. The contact between it and the magnesian limestone is sometimes sharp; but, at other times, a scale of iron oxide separates the two. The barite generally surrounds the galena, but crystals of the latter protrude beyond the barite halls, and the faces of the galena crystals are often well developed in the mass of the barite. The faces of some of the galena crystals are coated with white crystals of barite, showing later deposition of the latter. Large quantities of ore were found in the surface clay here, associated with broken chert. Calcite is rarely found, and no zinc was observed.

The Bruin diggings were in the SE. $\frac{1}{4}$ of section 27 of the same township. Here, according to Schmidt, galena was found in small seams traversing the limestone, and also loose in the surface clay, and along the limestone walls and in cavities in that rock. It was associated with granular barite.

In section 34 of this township were the *Dayton-Williams diggings*, which worked deposits like the last.

The Anderson diggings.—These were in the SE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 35. Galena was found at depths of a few feet, in a spongy, fossiliferous chert, partly broken, and the fragments cemented by galena. This breccia was from 6 ins. to 2 ft. thick, and lay horizontally above limestone of irregular surface, with red or brown clay or loam separating the two and filling the inequalities of the limestone.

The Murphy diggings were south of Linn Creek, in section 36, township 39 N., 17 W. Most of the galena was found in the surface clay, which was in places over 50 ft. thick. This seam of ore also penetrated the limestone.

The Ferry diggings were about a mile and a half southeast from this, in sections 5 and 6 of township 38 N., 16 W. The galena was found associated with limonite in the red surface clay and broken chert.

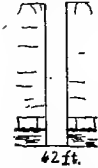
The Charles Parsons diggings.—These are about the middle of the south line of section 22, township 38 N., 16 W. They were visited by the writer in November, 1893. A crevice was then seen running through magnesian limestone in the bed of the branch. The course varied from NNE. to E. Galena was found in this crevice in "chunks" imbedded in barite. Little more than prospecting had been done so far.

The Old Harold mines, now abandoned, are about a mile south of Toronto, which is in section 25, township 38 N., 15 W., near the county road. They were worked before the war and also about 20 years ago, and from that time to 1886 probably over 100 tons of lead were mined. A furnace was built here about 1876. Most of the ore was obtained from surface clays, though some came from the rock. About 1885, a shaft was sunk to a depth of 100 ft., but nothing remunerative was found. A good deal of this ore in early years was hauled to Linn Creek.

Jackson mine (R.)—This mine is located near Barnumton, in section 19, township 39 N., 18 W. It was visited by Mr. Robertson in 1891. The main shaft was 130 feet deep, and was sunk in a pocket of Coal Measure shales, which it penetrates for its entire depth. These shales are quite bituminous, having at times thin seams of coal and pure bitumen interstratified with them. At a depth of 40 feet from the surface, a drift showed the shale-beds dipping strongly toward the shaft. As the margin of the pocket was approached, masses of limestone and chert, not very abundant toward the center of the pocket, are frequently encountered, and the lines of deposition of the shale follow with more or less regularity the outlines of these masses or boulders. The ore, consisting entirely of zinc blende of a very dark color, occurred interbedded with the shale from the top of the shaft to the bottom, but at a depth of 40 feet it was rather more concentrated. The surrounding country rock is a close-grained, earthy, drab-colored magnesian limestone. Mr. A. R. Jackson, of Climax Springs, is the manager and principal owner of the property. No ore had been shipped at the time of inspection.

A few miles southwest of this mine, other developments have been made during recent years by Mr. Jackson, which were visited by the writer in September, 1890.

In section 33, township 39 N., 18 W., were two shafts sunk near the center of the section, one a few hundred feet north of the other. The northmost shaft struck a vein at a depth of 40 feet, running N. 30° W. (mag.), and about 80 inches thick. It dipped about 80° E. The walls were of magnesian limestone; the crevice was partially filled with galena and zinc "silicate."



The lower or southmost shaft was about 100 feet deep. The vein ran nearly N. 18° W. and dipped to the west about 85°. The wall-rocks were magnesian limestone and chert, and the enclosed vein consisted of a thin seam of galena, at points less than 1 inch in thickness.

The Caldwell shaft.—This was in the NE $\frac{1}{4}$ of the SW $\frac{1}{4}$ of section 4, township 38 N., 18 W. The shaft was about 42 feet deep, and was sunk on a chimney or opening in the rock. The ore, consisting entirely of galena, was along a horizontal opening, 2 ft. high, in a red plastic clay, associated with fragments of chert. These openings lay between beds of limestone with very irregular surfaces. These conditions of occurrence are illustrated in the adjoining figure.

The Wheeler mines.—These are located in the SW $\frac{1}{4}$ of section 32, township 37 N., 16 W., and in the adjoining section to the south in Laclede county. An opening here was formerly known as the Fielding-Clark diggings, but we now call them the Wheeler diggings from the fact that they are on and adjacent to lands of Sam Wheeler. The geology of this vicinity has already been described in chapter XI, and need not be further discussed here. A pit sunk on the outcrop of the pegmatite did not reveal any ore; but, about 150 ft. southwest of this, shafts were sunk in the limestone, from which some little galena and blende were obtained. These struck crevices which cut the limestone in every direction. The metalliferous mineral was of peculiar appearance, of rather earthy luster and of a blue-black color; pyrite was associated with it. An analysis showed the following remarkable composition:

ANALYSIS LEAD-ZINC ORE—SAM WHEELER LAND.

Anal. Mo. Geol. Sur. No. 325. J. D. Robertson, Anal.

Cu Fe S	0.0071
Fe S ₂	3.8308
Zn S	22.1671
Sb ₂ S ₃	Tr.
As ² S ₃	Tr.
Pb S	63.9950 by diff.
	<hr/>
	100.000

Silver, $\frac{1}{2}$ ounce to the ton.

The country rock is a fine-grained crystalline, magnesian limestone, rather hard; sometimes this is brecciated along the crevices and cemented by the ore. About a quarter of a mile farther southwest, another shaft was sunk, and revealed small quantities of similar ore. The result reached by the developments so far are not encouraging for future work; the pegmatite seems to have no direct connection with the presence of the ore.

HICKORY COUNTY.

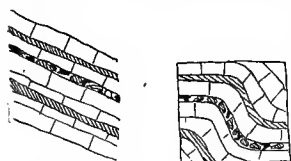
More or less prospecting for both lead and zinc ores has been done in this county during recent years, and similar efforts to discover workable deposits have been made in past years. Nearly 500 tons of ore are reported to have been mined, but no exact record of productions has been obtained. Opportunities for observation are very poor.

Seed Tick diggings—These are near Cross Timbers, in section 18, township 38 N., 21 W. Mr. Robertson, who visited the locality in 1891, describes the deposit as a succession of pockets in the magnesian limestone, with an apparent course of about N 80° E. In these pockets galena occurred in large irregular masses and in crystalline forms; the enclosing limestone was of a buff color, earthy, soft and partially decomposed. Several individuals were working here at the time, and had raised considerable quantities of ore.

The Carter diggings, in the SW. $\frac{1}{4}$ of the NE. $\frac{1}{4}$ of the same section, were described by Schmidt as operating a small vertical vein of galena about $\frac{1}{2}$ in. thick, running E.-W., through soft, earthy magnesian limestone. Barite was associated with the galena.

At the Barytes diggings, in the NE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of the same section, ore was found under similar conditions.

At the Stearns diggings, in the SE. $\frac{1}{4}$ of the SE. $\frac{1}{4}$, a shaft 20 ft. deep was sunk on a similar vein of barite, in gray magnesian limestone, with an E.-W. course. This contained galena, copper pyrite and blende. The thickness increased with depth.



SIDE OF DRAFT.

END OF DRAFT.

FIG. 266. Section in the Tatum mines.

The Daniels and Brown diggings were in sections 12 and 13, township 38 N., 22 W. Schmidt states that galena was found both in crevices and in crystals disseminated through the rock.

The Tatum mines (R.)—These are situated in section 11, township 36 N., 22 W. They were visited by Mr. Robertson in 1891, who describes the deposit as follows: A shaft was sunk 60 ft., in a compact, earthy limestone, in which much chert occurred in lenticular masses. The shaft was located near a sink-hole, and the strata of limestone and chert in the vicinity were tilted and crushed. The disturbed condition of the rocks, as exhibited in one of the openings, is illustrated in the adjoining figure.

In this opening one stratum, composed partly of clay, was essentially a chert breccia, the fragments cemented together by galena, which, on account of the limited space for deposition, had crystallized in distorted forms. The presence of the sink-hole near by can hardly account in full for the disturbances of the strata. The galena was evidently deposited subsequent to the forming of the depression.

In this same vicinity there were other small prospects on the bank of a small creek in section 33, township 37 N., 22 W., and also in section 2 of township 36 N., 22 W. They appear to be irregular pockets of barite in limestone, carrying more or less lead. No mining has ever been done here. The Brookfield Mining company, in sections 21 and 22 of township 38 N., 22 W., have prospected considerably, and have found some good lead and zinc ore. They are not doing anything now.

The fact that transportation is so high in this county, there being no railroads running through it, probably tends to check much enterprise in the way of prospecting.

The ore from the vicinity of Cross Timbers is hauled to Warsaw, a distance of about 25 miles. That produced near Wheatland and Hermitage is usually hauled to Collins, on the Clinton branch of the Kansas City, Fort Scott & Memphis railway, a distance of 20 miles or more.

The Pomme de Terre Mining company's property is situated about nine miles NE. of Wheatland. They had taken out considerable lead, probably 20 tons, but were idle at time of inspection.

The Thatch mine, 5 miles SE of Wheatland, have good blende on their land. The works were idle at the time of inspection.

In township 38 N. 22 W., sections 7, 18, 19 and 20, and in township 38 N. 21 W., sections 10, 11, 12, 13, 14 and 24, some 40 or 50 prospecting shafts were put down some years ago, and, according to a communication of Prof. Broadhead's to Major R. H. Melton of Kansas City, galena was found in 11 of them in large quantities, associated with barite, also zinc and some copper in one shaft. Major Melton states that millions of pounds of lead and zinc have been taken from this tract.

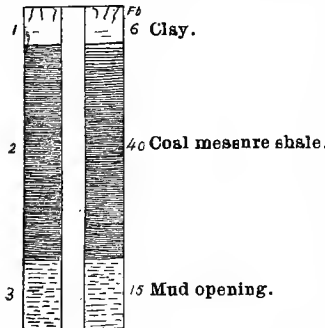
BENTON COUNTY.

More or less mining has been done in Benton county since the discovery of the Cole Camp mine, 50 years ago, but the period of most active operation was about the year 1878. Only a few hundred tons of lead ore have been produced altogether, however, and only a few tons of zinc ore, though the deposits are reported to be very promising. At only a few localities are present conditions such that anything can be seen; thus most of the following descriptions are based upon previous reports, and upon communications of individuals who are familiar with the past history.

Cole Camp mines.—These are in the NE $\frac{1}{4}$ of the NE $\frac{1}{4}$ of section 32, township 42 N., 21 W. According to Shumard's report of 1867 to Major R. H. Melton, the owner of the land, ore was dug here from pits in the clay; later, several caves were encountered, containing galena, and a shaft was sunk to a depth of 35 ft.; at one point a lode of galena nearly one foot thick was encountered, running E.—W. Galena is found in the adjoining section 29, and large quantities of barite, also. Major Melton informs the writer that 150 tons of lead ore were produced from the Cole Camp mine before the war, and that millions of pounds of lead have been taken from these two sections altogether. A lead furnace was built here and the lead smelted, and the pigs shipped thence to St. Louis.

The Holderman mines (R.)—These are in the NE $\frac{1}{4}$ of this section 29, and were visited by Mr. Robertson in 1891. Several shafts had been sunk, one to a depth of 40 ft. The ore is mainly blende, and occurs in a crevice in the limestone, which is partially filled with a soft bluish shale. This shale is shot full of dark-colored "pebble-jack" or rudimentary blende crystals. No galena was noticed. The country rock is a hard, compact, earthy magnesian limestone. In some smaller prospects near by there were several diminutive pockets of barite in which small seams of lead were observed. These pockets seem to follow a general course of N 10 E.

About half a mile northeast, in the SW $\frac{1}{4}$ of section 22, township 42 N., 21 W., a small deposit of blende was encountered in clearing out a spring. About 2 tons were taken out of a pocket in the hard, compact magnesian limestone. It was associated with pyrite, the blende crystalizing around slender stalactites of the pyrite, much of which latter mineral had subsequently changed to limonite.



The Melton mines (R.)—These are situated in sections 17 and 18 of the same township, 42 N., 21 W., close to Melton station. They were also visited by Mr. Robertson, who describes them as follows: Two shafts had been sunk, one about 58 ft. deep, through clay and soft, compact earthy limestone. Much residuary galena was found in the clay, and a crevice in the limestone about 18 to 20 inches wide was filled with barite, in which veinlets of galena ran in various directions. About 100 yards from this shaft another was sunk to a depth of 61 ft. A section of this shaft is here given. In this shaft much blende was found in the Coal Measure shale. This was dark red in color, in separate crystals partly corroded, and known locally as "pebble jack."

Major Melton states that large quantities of lead and zinc ore have been mined from this tract, and that in a ditch about

FIG. 267. Sec. shaft at Melton mines.

100 ft. long and 60 ft. deep, a vein of lead 32 inches thick was shown in places. Prof. Broadhead has expressed the opinion from his observations that the deposit is a fine one, and occurs in a "regular vein" containing both lead and zinc ore, and Dr. Shumard has also given a very favorable opinion concerning this and the Cole Camp deposits.

The White diggings.—These are in the NW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 28, township 39 N., 21 W. Shumard describes a vertical crevice here in soft, gray magnesian limestone, along which numerous pits had been sunk from 8 to 25 ft. deep, for a distance of about 300 ft., in a direction a little E of N. In the crevice, barite was abundant along with the galena. In the Gustka diggings adjoining, shafts 20 ft. deep were sunk through sandy magnesian limestone, in which small quantities of galena were found mingled with barite.

In section 9, about three miles north of the last, on Turkey creek, some good galena has recently been found. A small smelter was erected here in past years. Major Melton has called our attention to the fact that a large quantity of barite has been found here also.

The Hopkins diggings.—These were in the NE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 2, township 39 N., 22 W. As described by Shumard, a shaft was sunk here 54 feet deep, upon a vein of calcite containing azurite and galena. The vein continued down to the bottom of the shaft. In sections 5 and 6 of the same township, and in section 1 of the township to the west, a number of prospect shafts have been sunk, and, according to Major Melton, galena and barite have been found.

The Deer Creek mines.—These were also described by Shumard, and were in the E. $\frac{1}{4}$ of the SE. $\frac{1}{4}$ of section 6, township 39 N., 20 W. Three shafts were sunk to depths of 25 feet. Galena was found associated with barite imbedded in sandy clay and in crevices in magnesian limestone. Small quantities of galena were found elsewhere in this section.

In township 41 N., 21 W., sections 29 and 30, some eight or ten shafts were sunk, none of them 30 feet deep, from which, according to Major Melton, lead and zinc ore were obtained.

Outside of the counties of the Central district thus far described, there are a number of deposits in adjacent counties, portions of which are included in the district map. These we will now proceed to describe briefly, beginning with Cooper county on the north, and continuing thence first west and then south around the border of the district.

COOPER COUNTY.

In the extreme northwestern corner of Cooper county more or less lead mining was done during early years, but recently nothing more than prospecting has been conducted here.

The Old Scott diggings.—These are the most noteworthy in the county. They are situated in the NE. $\frac{1}{4}$ of section 28, township 49 N., 19 W., on Black fork of Lamine creek. The deposit was described by Swallow in 1854, but at that time little work had been done. A shaft 26 ft. deep had been sunk, and a drift was run thence about 31 ft. northeast, in the direction of the lode. The ore, consisting of galena associated with barite, occurred in "Burlington" limestone. Schmidt states in 1874 that a new shaft 25 to 30 ft. deep had been sunk, and seams of barite were found running between and across the limestone strata. The limestone beds here alternate with thick layers of fossiliferous chert. A large amount of barite was found about these diggings, and a mill was erected a few years ago for grinding it; little work was done, however.

The Collins diggings.—These diggings were about two miles northeast of the Scott, in the SE. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 19, township 49 N., 18 W. Here, Schmidt describes shallow shafts in clay and broken chert. Galena and barite were obtained in this clay and also adhering to masses of softened limestone. Masses of brown smithsonite were also found, containing much iron and enclosing crystals of blende. A layer of galena occurred, a few inches thick, dipping southeast into the hill, at an angle of between 20 and 30°, and following the surface of the solid, coarsely crystalline, Lower Carboniferous limestone. Copper pyrite was also found here in considerable quantity. It has been reported to the writer that as much as \$25,000 worth of lead was taken from this deposit, but this figure seems extreme.

On the Willis land, in the W. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 5, township 48 N., 18 W., seams of barite several inches wide with specks of blende were seen by Schmidt, traversing crystalline Encrinital limestone. At several other localities in Cooper county, specimens of lead and zinc ore have been found.

SALINE COUNTY.

Only a little prospecting has been done in this county during recent years, though in the past, considerable quantities of lead ore are reported to have been mined.

The Marmaduke diggings.—These are about the only ones worthy of note in the county. They were briefly described by Schmidt in 1874. They are located almost in the channel of Saline creek, in the SW. $\frac{1}{4}$ of section 19, township 49 N., 19 W. Operations were in progress here in 1891, when visited by the writer, but no regular deposit was exposed, only a little galena associated with barite, scattered irregularly through the Lower Carboniferous limestone, being seen. As reported by Schmidt, one shaft followed a crevice filled with loose masses of barite and galena; at 15 ft. an opening containing considerable quantities of ore was struck. A furnace was built, and it is stated that some \$3000 worth of lead was mined, also a large amount of white, pure barite.

PETTIS AND ST. CLAIR COUNTIES.

In Pettis and St. Clair counties some fragments of lead and zinc ores have been found, and some little prospecting in the search of deposits has been undertaken. Nothing, however, specially productive of results or worthy of note has been discovered.

POLK COUNTY.

In several places in this county, fragments of lead ore have been found, but little or no prospecting has been done. Mr. Robertson notes that on the Plummer farm, in sections 10 and 11, township 35 N., 21 W., considerable lead ore has been mined, but no work has been done there for some years, and no observations are recorded. In section 10 of the same township, on Enloe creek, some little lead ore has been found in the surface clays.

In township 34 N., 21 W., section 3, on Liedley creek, Mr. Thomas Barger sank a shaft some 50 ft. deep. Galena was found at the surface in the clay, and several veins of galena are reported to have been struck deeper down, yielding between one and two tons of galena.

In township 35 N., 22 W., sections 31 and 32, and in township 32 N., 24 W., section 24, small fragments of lead and zinc ore have been found.

Prospecting in the southern part of the county, about Graydon Springs, has already been referred to on p. 629.

DALLAS COUNTY.

In Dallas county quite a little lead mining has been done in past years, but it was confined principally to two or three localities. Prospecting has been done at a number of points, and occurrences of lead ore have been observed at many more. During recent years but little work has been done, and most of the information concerning these ores has been derived from interview of individuals who conducted mining in the past.

Rambo shaft.—This has been the most important deposit in the county, and is estimated to have produced about 500 tons of lead ore. It is in the SW. $\frac{1}{4}$ of the SW. $\frac{1}{4}$ of section 1, township 35 N., 19 W., on the top of a bare knoll, on the edge of a prairie. This is nearly the highest point

in the neighborhood. When visited by the writer, in December, 1893, there was nothing to be seen but the outline of a circular pit, now completely filled in. The following information is derived

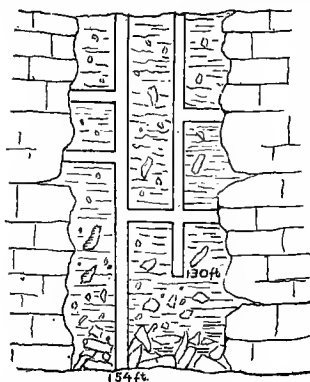


FIG. 268 Section of Rambo shaft.

from an interview with Mr. Rambo, who operated this deposit. The ore occurred in a chimney 60 ft. in diameter, within which three shafts were sunk, one 154 ft. deep and the others 130 ft. each. The upper 30 ft. of the deposit was taken out in an open cut of a shape shown in the adjoining sketch. No cap rock overlay the deposit. The filling was made up principally of red clay, with only a few blocks of chert or sandstone, though sometimes a horizontal sheet of chert was encountered, but this was not continuous across the pit. No coal or black shale were found. The upper portion of the filling was bleached partly white to a depth of 20 ft., and here some cerussite was found. Through the red clay the galena occurred in bunches distributed over the whole width of the deposit, and did not preponderate near the margin, as in the case of the circular deposits already described. No ore was attached to the walls. The latter were very irregular, with clay-filled crevices, but these contained little galena. At the bottom of the chimney were many blocks of limestone and chert and of sandstone, surrounded by clay. Ore was not found in quantities below a depth of 80 ft., and most of the ore was taken between the depths of 10 and 60 ft. The ore was mostly in the form of what is known as "chunk mineral," the lumps ranging up to 100 pounds in weight. The ground was very soft, and much timbering was necessary in the shaft and in the drift, which extended from the latter to the wall rock. The deposit was almost entirely worked out by Mr. Rambo during the two years between 1868 and 1870. The wall rocks were of the common Lower Silurian magnesian limestone and chert.

A few miles north of the Rambo mine are what are known as the *Hildebrand diggings*, whence more or less lead ore has been obtained in past years. The *Nasatrod diggings* were in the SE. $\frac{1}{4}$ of section 35, township 36 N., 20 W., about eight miles west of the Rambo. These produced lead ore in the past but are not open now.

In township 35 N., 19 W., a shaft has recently been sunk in section 35, about six miles south of Rambo, to a depth of 60 feet. Zinc blende is reported to have been encountered here and the showing is said to be very encouraging. Prospect shafts have also been sunk near Wood Hill postoffice in the same township, but no definite results were accomplished.

Near Buffalo, in township 34 N., 20 W., section 25, in the NW. $\frac{1}{4}$ of the NE. $\frac{1}{4}$, a shaft 80 feet deep was examined by the writer, penetrating magnesian limestone. No crevice was seen, the rocks were not disturbed, and only a little galena was found in small bunches. About two miles northeast from here, in township 34 N., 19 W., section 20, in the SE. $\frac{1}{4}$ of the NE. $\frac{1}{4}$, on the east side of the river, about half a ton of galena was taken out of pockets in the side of a bluff of magnesian limestone. At the Zugler diggings, in Sugar Tree hollow, in section 22, about two miles east of the last, a little galena was also obtained.

In township 34 N., 18 W., in the southern part of section 5, lead occurs in pockets in broken limestone and chert associated with red and white clay. No vein is reported here. A shaft 30 to 40 feet deep has been sunk recently, from which lead ore has been obtained.

About five miles southeast of Plad postoffice, lead ore is also reported to have been struck in a well, and considerable quantities, we are informed, have been dug recently on O'Bannon prairie, near Spring Grove, in the southern part of the county.

LACLEDE COUNTY.

In Laclede county, specimens of lead ore have been found at a number of different localities, but outside of the developments near Decaturville, described under Camden county, no work has been done in the way of mining, and no production of lead ore is credited to the county.

PULASKI COUNTY.

Pulaski county, like Laclede, contains nothing that we can call a lead mine. Near Richland some prospecting has been done, and small quantities of lead and zinc ore are reported to have been found. At Waynesville, Shumard refers to a few small fragments of lead ore encountered in wells. Beyond this, we have been able to learn of no developments.

PHELPS COUNTY.

Very little prospecting has been done in this county. On Bull creek, in section 4, township 36 N., 9 W., some fragments of blende of good quality were found in the bed of the stream. A prospect was opened here in 1874, by Messrs. Burns and Shotwell. Several tons of blende were obtained here and in the immediate vicinity, at very shallow depths, in crevices in the rock.

Shumard, in 1856, reports an occurrence of galena in a cave on Little Piney creek, in section 19, township 36 N., 8 W. It was found here in small seams of barite, which extended from the entrance of the cave back a distance of 300 ft. He also notices the occurrence of galena in a sandy magnesian limestone over the hills, in section 35, township 36 N., 9 W.

MARIES COUNTY.

In the eastern portion of this county more or less lead is known to exist in the residuary deposits, although very little prospecting has been done there. Mention is made in previous reports of several occurrences which we will refer to. The recent developments at Vichy were examined by Mr. Robertson.

Future Great Mining Company (R.).—This company is located at Vichy, in the NW. $\frac{1}{4}$ of the NW. $\frac{1}{4}$ of section 14, township 39 N., 8 W. It had erected an elaborate plant for working the mine, which was not in operation at time of inspection. The shaft is sunk for a depth of 90 ft., in very hard, dense, siliceous limestone with small cavities lined with quartz crystals. The ore is entirely zinc blende, of a very fair quality. This is very dark, nearly black in color, and occurs in nearly spherical nodules possessing a radiate structure on breaking. The blende sometimes encloses small crystals of pyrite. The form of the deposit could not be determined, as everything was fallen shut.

The Williams mine.—This is briefly referred to by Broadhead as located on Upper Maries creek, in township 39 N., 10 W., and as opened in 1874. Nothing has been done there during recent years. According to Mr. C. W. Crisman of Tavern postoffice, the ore was found in a vertical crevice with lenticular openings; its course was about N.-S. or perhaps somewhat W. of N. It was worked at intervals for half a mile, some 30 or 40 pits being dug; the deepest shaft was 40 ft. The filling of the crevice consisted of barite and clay. The deposit was discovered before the war, and was worked at different times since. During the latter years of work, it is reported that fully \$2000 worth of lead ore was taken out from the "Old" shaft. In addition, large amounts were mined from other openings up to 1880.

In township 41 N., 11 W., section 20, Broadhead reported, in 1857, the finding of fragments of galena and barite. In township 40 N., 11 W., section 34, he describes a vertical opening in magnesian limestone, 4 ft. wide, running nearly E.-W., containing galena associated with oxide of iron. At other localities, specimens of galena have been found.

Dr. Shumard, in the report of 1855-1871, refers to the finding of galena in small pieces in sections 24 and 32, township 39 N., 7 W. He further quotes Mr. Engleman as reporting the occurrence of lead ore in section 8, township 39 N., 8 W., where about 35 pounds were obtained in 1856, and at Rocky Branch of Spring creek, as much as a ton has been raised in one season.

OSAGE COUNTY.

In Osage county specimens of lead ore are occasionally found, as in all of the counties in this part of the state. No developments have been made, however, and nothing can be said as to the conditions of occurrence. In the report of 1855 to 1871, Prof. Broadhead refers to the discovery of lead ore adjacent to a contact of sandstone and magnesian limestone near the middle of section 17, township 41 N., 11 W.

APPENDICES.

- A. A Study of the Cherts of Missouri.
- B. Methods of Analysis.
- C. List of References.

APPENDIX A.

A STUDY OF THE CHERTS OF MISSOURI.

By Edmund Otis Hovey, Ph. D.

The investigations herein reported were carried forward on material collected by the officers of the State Geological survey of Missouri, and kindly furnished me by Mr. Arthur Winslow when State Geologist, together with a long list of references to the literature on the subject of flint and chert. The chemical analyses which will be quoted were made, unless otherwise stated, at the office of the Survey, by Mr. J. D. Robertson. Thirty-nine specimens from different parts of the State, and fifty thin sections made from them, were examined.

GENERAL DISCUSSION.

The material falls naturally into two groups, according to geological age. About half of the specimens came from the Ozark* series, and the rest from the Lower Carboniferous, mostly the Burlington stage. It is aside from the purpose of the writer to discuss the geologic relations of the cherts; but the Lower Magnesian cherts examined present some features which separate them more or less sharply, lithologically, from the Lower Carboniferous ones. The former contain comparatively few fossils, while the latter are usually crowded with stems and plates of crinoids and other fossils, or the cavities left by their removal, though occasionally a Lower Carboniferous chert is found which shows no indication of organic remains.

In both groups the color varies very much from pure white to gray, while very many of the cherts are stained brown or black by iron, and an Ozark specimen (No. A 4778) is a decided pink. The texture, likewise, is very various, some specimens (*e. g.*, A 2912 and B 3025) being very dense, aphanitic to the naked eye, and without fossils or cavities, while others are vesicular from the solution of pebbles (A 3119), or are full of cavities from the removal of fossils (B 3180, 5115). There is great difference, also, in the state of preservation of the chert, much of it being almost perfectly fresh except for an outer shell of decomposition (A 2912, 3061, B 5060, 5070), while other has suffered alteration throughout its mass, as is shown in several specimens of the Ozark series and in the heavy beds of "tripoli" in the Lower Carboniferous at Seneca and elsewhere.

*The term "Ozark series," used in the chapter on cherts, is the equivalent of the term "Lower Magnesian," used by the author in his article on Missouri cherts in the *American Journal of Science*, Nov., 1894.

PETROGRAPHY.

These cherts consist almost entirely of chalcedony, or silica in the chalcedonic state, but quartz and opal are present to some extent in some of the specimens. The slides are almost colorless and featureless under the microscope in ordinary light, but in polarized light the structure of the rock is very clearly indicated, and is shown to be a very fine-grained mosaic, mottled by reason of variation in fineness of grain. In several of the specimens from the Ozark series, notably No. A 4209 from Morgan county, the material is aggregated into small spherules. These are optically negative, which proves that they are made of chalcedony. Chalcedony has a higher index of double refraction than quartz, but the polarization colors in these sections rarely rise above gray of the first order, because the grains, whether in mosaic or in concentric spherule, are too small to give the thickness required for the higher colors. For photomicrographs showing the mosaic and concretionary or oolitic structures of chert, the reader is referred to Irving and Van Hise's treatise on "The Penokee Iron-bearing Series of Michigan and Wisconsin," 10th Ann. Rep. U. S. C. S., 1890, Pt. 1, Pl. 24, fig. 2, and Pl. 28, fig. 2.

The presence of opal silica is indicated in some of the slides (A 5005, etc.) by apparently amorphous areas, but possibly with more definiteness in other specimens, by the solubility of a portion in K O H (caustic potash), though, as will be shown, even this is not a certain criterion.

Quartz occurs in the cherts as well-terminated crystals of some size, more or less completely filling cavities in the chalcedony, as drusy coatings to cavities, and as well-rounded grains which may or may not form the nuclei of spherules. The crystallized quartz seems to be secondary to the chalcedony in its deposition, or to form the last phase in the aggregation of the cherts—the latter appearing to be the case where seams of coarsely granular chalcedony grade into lenses of finely granular or crystallized quartz. The strictly secondary quartz lines or fills cavities in the chert, without having any apparent connection with the chalcedony. The rounded grains are evidently quartz sand, which has been caught within the chalcedony as it was depositing or aggregating. From the frequent occurrence of inclusions in them, they are probably granitic in their origin, and this view is strengthened by the rare presence of a grain showing the multiple twinning lamellæ of microcline (A 4210, 5036a). Dr. C. R. Keyes [131, p. 451] describes cherts from the Lower Carboniferous (Burlington) of the northeastern part of the State, which "upon exposure to the weather quickly slacken like quicklime to a fine intensely white powder." This would indicate that the silica in them was amorphous, but specimens of this character were not sent the writer.

Scattered through all the slides, there are minute irregular scales and specks of a yellowish brown to black substance, which may be referred to amorphous iron oxide (limonite), though some of them are more probably grains of magnetite. A noteworthy feature of most, if not all of the thin sections, is a "dusty" appearance as seen in ordinary light. This dust disappears to a considerable extent when the light is cut off from the upper side of the section. The phenomenon may be due to clayey-matter present in the rock.

In view of the discovery by Professor H. A. Nicholson [158, p. 56] and Dr. G. J. Hinde [103, p. 40], of Radiolaria in chert from the Lower Silurian (Ordovi-

cian) strata of Scotland, and by Professor W. J. Sollas [210, p. 141] and Dr. Hinde [104, p. 435], of sponge spicules in Carboniferous chert from Ireland, very careful search was made through these Missouri cherts for indications of anything of a similar nature. Nothing whatever of this kind was found, with the possible exception of some slender cylindrical rods in a specimen from the Lower Carboniferous at Webb City, in Jasper county (B 3740). The rods are noticeable in cavities in the rock, and the one which was measured was 2 mm. long by 0.12 mm. in diameter, but it seemed to have been thickened by some extraneous deposit. What appear to be the cross-sections of these rods have nuclei of brown matter surrounded by clear chalcedony, but sometimes several exactly similar nuclei string themselves together within a common shell of chalcedony. Between crossed nicols there is no line of demarkation between these bodies and the matrix, all is granular chalcedony. I hesitate, therefore, to refer these rods to sponge spicules.

Many of the Lower Carboniferous cherts are highly fossiliferous, being more or less crowded with the remains of erinoids, brachiopods and corals. These remains, however, are calcareous in nature, and form a breccia with the chalcedony of the chert as the cement, though in the cherts described by Dr. Keyes, the fossils have been silicified. A specimen from this group at Grand Falls, Newton county (B 3706), shows several sections of a branching form of *Stromatopora*, and this genus also occurs in chert from Sulphur Springs, Arkansas.

The chalcedony occasionally shows a tendency to form concretionary granules. In the specimen just cited (B 3706) there are true fibrous sphaerocrystals, which give a black cross in polarized light. The pronounced granular or oolitic character is confined to five of the specimens of the Ozark series in the suite under discussion. In some of these the chalcedony has formed granules without any apparent foreign nucleus, while in others rounded grains of quartz were the nuclei of deposition. Siliceous oolite seems to be a comparatively rare rock. It was noted by C. W. Featherstonhaugh [86, pp. 54, 55] in Wayne county, Missouri (?), Tennessee and Kentucky, and reported as "silicified oolite" of Carboniferous age, but his stratigraphy is not to be depended upon. Concretionary or granuliferous chert is one of the three divisions made by A. Renard [188, p. 494] in his study of the Carboniferous cherts of Belgium. A preliminary microscopical and chemical investigation of siliceous oolite was made by E. H. Barbour and J. Torrey [7, p. 246] on specimens sent them from Centre county, Pennsylvania. Since then the rock has been reported a second time from Tennessee [237, p. 2], and it appears probable from an able discussion of the Pennsylvania oolite by Dr. W. Bergt [113], which first came to the present writer's knowledge some months after his own article [113, p. 627] on the same subject had been published, that several rocks from widely separated parts of the world, and described under other names, really belong in this category. Our specimens, therefore, add five localities for this interesting rock: (3061) Wright county, (3119) Camden county, (4209) Morgan county, (5034) Osage river, and (5036b) Taney county, in Missouri, and oolitic chert has been reported from various other localities in the area of the Ozark series.†

†Oolitic cherts are very abundant in the Ozark series of Missouri, and are found almost everywhere over the Ozark area. Beds essentially oolitic throughout, a foot or two in thickness, are frequent.

Besides these, another of the Ozark localities furnishes a rock (A 5091) which is partly oolitic in structure, and two others (A 4210 and 5036a) give rocks in which rounded grains of quartz have been cemented in an abundant matrix of chalcedony without the formation of concretionary spherules about them. In one of the latter (5036a), however, the chalcedony shows that there was some tendency within it to form shells about the quartz grains, and an occasional small spherule of chalcedony may be seen in the matrix.

CHEMISTRY.

As was to be expected from the microscopic characteristics, the cherts, when not fossiliferous, are almost pure silica. The analyses made by the Missouri Geological Survey show a much higher percentage of alumina and iron oxide than is present in the cherts from the same strata and the same general region which were analyzed by the U. S. Geological Survey, but this difference is probably due to the fact that the specimens analyzed by the Missouri survey were selected more to illustrate the transitions between cherts and other rocks than to exemplify pure chert. Mr. Robertson reports that in making the analyses $Al_2O_3 + Fe_2O_3$ was redissolved after the first precipitation and precipitated again, to make sure that no SiO_2 was included in the amount.

The percentage of soluble silica was determined in only four of these analyses. Prof. Seamon, in his report on No. 18 for the tripoli company, says that "7.28% of the silica was soluble in a 10% solution of caustic soda on boiling for three hours;" the U. S. Survey reported 4.52% in No. 5, 3.99% in No. 3 and 3.35% in No. 21, and that the determination was made in the following manner: The solution used was made up of one part of solid caustic potash to three parts of water, and one gram of the finely powdered chert was heated in each case with fifty cubic centimeters of the solution for one hour on the water-bath. No. 3 was somewhat porous; Nos. 5 and 21 were compact, the last showing occasional cavities filled with quartz crystals [92, p. 161]. These percentages, however, cannot be taken as the measure of the amorphous silica present in these rocks, for undoubted quartz is noticeably soluble in caustic potash, Rammelsberg [56, p. 193] finding from 5 to 7.75% of vitreous massive quartz thus soluble, and quartz crystals and quartzite tested for the Arkansas Survey [92, p. 164] gave from 2.59 to 6.28% soluble in this medium. The amounts given above for the Missouri cherts are below these maxima, and, therefore, do not necessarily indicate the presence of opal (amorphous) silica, since chalcedony is held to have the same chemical characteristics as quartz. When a large percentage of the silica is soluble in caustic potash, the presence of opal silica is indicated; *e. g.*, the Arkansas Survey chemist found 30.72% of a Silurian chert, 35.56% of a Tertiary chert, 88.38% of a geodized coral from Tampa, Florida, to be thus soluble. These geodized corals are known to be opal, and the two cherts must contain large amounts of amorphous silica. Edward T. Hardman [96, p. 88] analyzed a series of twelve specimens of chert from the Upper Carboniferous strata of Ireland. He tested the rocks in hydrochloric acid, and found traces of soluble silica in several and 1%, 1.22% and 1.5% in three cases. All the Cretaceous chalk flints contain much opal silica and show high percentages of silica soluble in caustic potash [174, ii, pp. 321-22].

It will be seen from the table that the chemical difference between "altered" and "unaltered" chert is so very slight that they can be distinguished only by

TABLE OF ANALYSES OF CHEERTS AND CHEERTY LIMESTONES.

No.	Locality.	Loss by ignition	Silica.		Alumina	Calcium carb- onate	Magnesium car- bonate	Alkalies	Total	Analyst.	Survey Nos.		Remarks.
			Combined oxide	Ferrie ox- ide							Analysis.	Catalogue.	
1.	Barry county, Henderson mine	.....	98.23	2.18	.....	.....	.....	.....	100.41	Robertson.....	360	2989	Compact, hard, white, sub-translu- cent.
2.	Howell county, Olden.....	.....	89.45	0.94	.....	9.44	.....	.....	99.83	"	411	4073	Partially decomposed, friable, buff- color
3.	Jasper county, Belleville	0.50	98.71	0.43	0.43	0.06	0.03	.....	99.73	U. S. G. S.	.....	.....	Altered; soluble silica* 3.91. Vol. III, Ark. Geol. Sur., 1890, p. 161.
4.	" " " " " "	0.42	98.92	0.48	0.48	0.06	0.08	.....	99.91	"	.....	.....	Altered.
5.	" " " " " "	0.78	98.17	0.83	0.83	0.03	0.02	.....	99.89	"	.....	.....	Unaltered; soluble silica* 4.52
6.	" " on Spring river.	34.95	124	124	63.16	0.24	.....	.....	99.69	Robertson	358	3697	Chert and limestone, intimately mixed.
7.	" " Joplin.....	.....	96.14	1.44	2.16	Tr	.....	.....	100.74	"	376	3778	Partly decomposed chert, Tucker mine
8.	" " " " " "	0.34	99.46	0.29	0.08	Tr.	.....	.....	100.17	U. S. G. S.	.....	.....	Gray, unaltered. Vol. III, Ark. Geol. Sur., 1890, p. 161.
9.	" " Webb City	.....	97.03	2.32	1.10	Tr.	.....	.....	100.45	Robertson.	367	3740	Partly decomposed (railway cut)
10.	Laclede county, Lebanon	.....	96.88	1.28	1.11	Tr.	.....	.....	100.47	"	373	3667	Opaque, compact, unaltered
11.	Lawrence county, Aurora	.....	91.25	1.25	6.52	0.17	.....	.....	99.26	"	351	3702	Calcareous-jobbing chert (chert ap- parently replaced lime)
12.	Montgomery county, Jonesboro	0.23	98.81	2.20	10.02	Tr.	Tr.	.....	100.19	St. L. S. & T. works	357	.....	Unaltered chert
13.	" " " " " "	1.04	91.04	0.84	1.27	0.17	0.16	.....	100.41	"	388	.....	Altered chert
14.	Newton county, Roaring Sp'gs	.....	94.91	2.85	0.75	Tr	.....	.....	98.51	Robertson.....	361	3626	Very compact, dense (partly decom- posed)
15.	" " Grand Falls	.....	63.67	2.20	53.12	0.57	.....	.....	99.66	"	365	3706	Quite calcareous
16.	" " Shoal creek	.....	44.34	0.45	54.07	0.72	.....	.....	99.66	"	363	3710	Silico-calcareous, lenticular layers.
17.	" " " " " "	.....	42.23	0.89	56.68	0.30	.....	.....	100.00	"	370	3700	Silico-calcareous, cherty layers
18.	" " Seneca	1.17	99.10	0.27	0.33	Tr	.....	0.23	.....	Rolla School Mines	374	3176	Decomposed chert, "tripoli"
19.	Arkansas, Sulphur Springs	.....	71.29	2.43	26.24	0.45	.....	.....	99.96	"	355	3707	Chert, with crinoid stems of calcite.
20.	Kansas, Galena	0.40	98.00	0.62	0.19	Tr	.....	.....	99.71	U. S. G. S.	.....	.....	Silico-calcareous
21.	" " " " " "	.....	.....	.....	.....	.....	.....	.....	.....	"	.....	.....	Slightly altered, soluble silica* 3.85.
22.	" " " " " "	0.20	99.13	0.16	Tr	0.02	.....	.....	99.61	"	.....	.....	Vol. III, Ark. G. S., 1890, p. 161.
23.	" " " " " "	0.50	99.23	0.22	Tr	.....	.....	.....	99.99	"	.....	.....	White, altered
	" " " " " "	.....	.....	.....	Tr	.....	.....	.....	.....	"	.....	.....	Blue, unaltered

* Soluble silica was determined arbitrarily in these rocks, by heating 1 gram, finely powdered, in 50 cc. of a solution of caustic potash (1 part KOH to 3 parts H₂O), for one hour on the water bath.

physical characteristics. The most completely altered chert is that from Seneca, which is minutely porous, breaks to pieces readily between the fingers, and may be ground to an impalpable powder in an ordinary mill. There is an extensive bed 18 ft. thick of this material at this locality, and it is quarried for the manufacture of filtering disks and tubes and of a high grade of polishing powder. A similar rock occurs near Seneca, in the Indian Territory, at Dayton, Newton county, Mo., and in township 4 S., 26 W., in central Arkansas [92, p. 384]. The Arkansas rock disintegrates to a fine powder on exposure to the atmosphere, but the Seneca rock does not.

Another item of interest in the analyses is the very low percentage of water (by ignition), which was found, especially in the pure cherts, whether altered or unaltered. This would argue against the presence of more than a very small amount of opaline silica. Mr. Hardman's analyses of the Irish Carboniferous cherts brought out the same fact regarding the presence of water.

ORIGIN OF THE CHERT.

There has been much speculation as to the origin of flint, hornstone and chert. The Cretaceous flints of the chalk formation in England and elsewhere contain so many remains of originally siliceous animal organisms (skeletons of siliceous sponges and polycystines), that some authors claim that all their substance has come from this source, while others contend that the silica of the flints is entirely due to chemical precipitation. Other theories lie between these extremes. A concise summary of the various theories which have been proposed to account for the flints is given by Professor Prestwich [174, ii, pp. 320-324], [see also 92, pp. 177-187], who gives, as his own opinion, the theory that silica in the colloid or soluble state was present as a chemical precipitate in the mud of the Chalk seas, and that this colloid silica, having a strong affinity for other forms of silica, gelatinous substances (like the sarcode of sponges), and other foreign bodies, aggregated about sponge spicules, replacing the sarcode as that decayed, and about the tests of echinoderms and the shells of molluscs. The irregular masses thus produced continued to grow so long as there was any colloid silica within the range of attraction.

The Carboniferous hornstone partakes so largely of the characteristics of the Chalk flints, that it probably had its origin in the same way [cf. 55, p. 257].

The upper Carboniferous cherts of Ireland were studied by Mears, Hull and Hardman [115, pp. 75-85], who came to the conclusion that the chert was essentially a pseudomorphous rock consisting of gelatinous silica replacing limestone of organic origin chiefly foraminiferal, crinoidal and coralline, the silica being a chemical precipitate from the sea-water of the period. M. A. Renard [188] came to a similar conclusion for the cherts of Carboniferous age in Belgium. This view has been vigorously combated by Dr. George J. Hinde [104, p. 435], who, starting from the discovery made by Professor Solias that there were sponge apicules in the Irish cherts, had numerous thin sections of the rocks made for himself. From the study of these Dr. Hinde decided that the cherts were wholly organic in origin, and that they were due to the aggregation and disintegration of the skeletons of siliceous sponges.

Pre-cambrian cherts have been studied by Irving and Van Hise [122, p. 347], in their work on the Penokee iron-bearing series of Michigan and Wisconsin.

This series belongs to the Huronian subdivision of the Algonkian system, and two of its four members contain much chert. The authors' conclusion regarding the origin of chert is: "First, that the chert was mainly deposited simultaneously with the iron carbonate with which it was so closely associated; and, second, that it is probable that the chert is of organic origin, although we have no positive proof that it is not an original chemical sediment, while it may in part be from both sources." This statement is made to apply with equal force to the other chert-bearing members of the series. [122, pp. 368, 397].

Dr. C. R. Keyes [131, p. 451] states that the fossils of the Lower Carboniferous chert of the northeastern part of Missouri have been silicified, and "numerous shells and crinoids are found partly imbedded in the chert and partly in the limestone, with a sharp line of separation, showing clearly that the siliceous impregnation had been acquired long after the original deposition of the beds, and was not due to a greater silicity of waters in which the calcareous were made."

Regarding the Lower Silurian and Lower Carboniferous cherts from southern and southwestern Missouri, the present writer's conclusion is that they are due to chemical precipitation, probably at the time of the deposition of the strata in which they occur or before their consolidation. In the Lower Carboniferous rocks crinoidal remains, brachiopodous shells and other calcareous fossils have usually formed the centers of attraction about which the silica collected. With one exception the fossils of the material studied remain as calcite, if they are present at all. The Lower Silurian cherts are irregular masses and are for the most part without any apparent centers of growth, except in the oolites, where sand grains are nuclei or the chalcedony has followed an inherent tendency to form concretionary masses.

NOTE -- The foregoing general discussion was read at the Brooklyn meeting of the Geological Society of America, in August, 1894, and appeared in the American Journal of Science for November, 1894.

DESCRIPTIONS OF SPECIMENS.*

A. FROM THE OZARK SERIES.

2912. "*Chert. Mansfield, Wright county.*"

The rock is very light gray, almost white in color; is very dense, and has perfect conchoidal fracture. The specimen is subcylindrical in shape and has a thin outer shell of material of chalky appearance, which is separated from the main mass by a very thin zone of iron oxide or iron-stained silica. This "chalky" shell gives no effervescence whatever with hydrochloric acid. Three thin sections were made of this rock: one transverse to the cylinder, one approximately normal to its radius, and one oblique thereto. Under the microscope the rock is so very fine-grained as to be almost aphanitic. This is especially true of the normal section, which is also very uniform in appearance. No radiating structure was detected, even in the transverse section, but this section was more mottled in polarized light than either of the others. A cloudy or dusty appearance was very noticeable, but it was largely removed by shutting off the reflected light, and it is probably due to the presence of clayey matter in the rock. Other specimens from Mansfield are described under Nos. 3061 and 3061a.

3037. "*Concentric nodule. Laclede county.*"

A very finely granular or saccharoidal rock, breaking with flat-conchoidal fracture. It is banded with stripes of light and very dark brown, which, under the microscope, are seen to be of very different coarseness of grain. In some bands the grains average about 0.03mm. in diameter, while in others the structure is almost aphanitic. Very minute (0.005mm.) dark spots are scattered through some of the darker bands, which seem to be scales of iron oxide, but may be merely cavities. They curve with the bands and diminish in numbers from one side of a band to the other. Frequently there is a sharp line of demarkation between a zone containing these spots and one entirely free from them.

3038. "*Quartzite. Sec. 2, Tp. 31 N. 28 W. Carter county.*"

This is a clear white granular quartz or quartzite, somewhat stained by iron.

3061. "*Oolitic chert conglomerate. Mansfield, Wright county.*"

A very dark gray rock which weathers white, brown or black, according to the amount of iron present. The fracture, which is flat-conchoidal and smooth, shows the granules very clearly. Most of them have a white center surrounded by a dark gray zone. They are imbedded in siliceous cement in which a grain of clear quartz may be seen here and there. The usual result of weathering has been that the granules have dropped out, leaving a pitted surface, but sometimes the converse has happened. In the thin section the granules are seen to be made up of a center of unoriented granular chalcedony, surrounded by a narrow zone of the same material arranged radially, with the minute fibres optically negative. The quartz grains are confined to the matrix, which is mostly chalcedony, but is partly quartz.

(3061a). "*Oolitic chert. Mansfield, Wright county.*"

This is a fine-grained, saccharoidal sandstone, loosely cemented together, not an oölite.

These descriptions of specimens are arranged according to geologic age and the catalogue numbers given them by the Missouri Geological survey.

*It must be borne in mind that the granular character of chalcedony is observable only between crossed nicol prisms (*i. e.*, in polarized light), and that very frequently the use of the same medium is necessary to bring out the fibrous character where that exists. The terms "coarsely" and "finely" granular are merely relative, and the former term is sometimes applied when the grains brought out between crossed nicols are only 0.05 mm. or even less in diameter. Grains 0.005 mm. in greatest diameter have been measured, and most of the slides show material even finer than that.

3119. "*Chert conglomerate. Cape Galena, Sec. 39, Tp. 40 N., 16 W., Camden county.*"

The specimen consists of dense, oölitic chert, flanked on one side by the same material containing many comparatively large cavities. For the most part these cavities seem to be the moulds of pebbles, but a very few are concavo-convex, suggesting an organic origin, such as the edge of a shell. Many small, well-rounded grains of quartz appear in the thin section, some of which are surrounded by a zone of unoriented, granular chalcedony. Some imperfectly concentric aggregates of chalcedony are present.

3667. "*Chert. Lebanon, Laclede county.*" *Analysis No. 10.*

This is a white, chalky rock, similar to other decomposed cherts from the state; but retaining an occasional lens-shaped nodule of flinty matter. In the specimen under examination one of these lenses has been broken across twice, and the pieces separated and faulted a little. There is a distinct lamination in the chalky portion, with wavy lines in the lamination. The rock is rather hard and very brittle, but not crumbly, is somewhat rough to the touch, and is adherent to the tongue. In the thin section the lamination is seen to be due to alternating degrees of fineness in the granular chalcedony. The lenses are usually more finely granular than the matrix, but some of them have a core of relatively coarse-grained material. A zone of minute cavities (?) of irregular shape and no apparent relation to each other surrounds a large part of one of the lenses.

4073. "*Decomposed chert or siliceous limestone. J. C. Evans' shaft, Olden, Howell county.*" *Analysis No. 2.*

A very porous, relatively light rock, which easily crumbles to powder between the fingers. The cavities are spheroidal, and the rock may be the residuum of a siliceous limestone. Consult the analysis.

4209. "*Chert. Morgan county.*"

This is a regular siliceous oölite, in which rounded grains of granitic (?) quartz have become the nuclei for the deposition of chalcedony to form granules, and these have been cemented together by a further deposit of chalcedony. The nuclei are large in proportion to the size of the granules. Sometimes in the cuspidate spaces between the spherules, the matrix takes on the handed form familiar in agate. The matrix is more coarsely granular than is the chalcedony of the spherules, though some of them show a deposit of rather coarsely granular chalcedony on one or more sides of the quartz nucleus, within the very finely granular outer shell. In other spherules there have been three zones of deposition—fine, coarse, fine again—around the nucleus. Relatively few of the granules consist of a rounded mass of coarsely grained chalcedony within a shell of very fine material. This rock closely resembles the siliceous oölite from State College, Center county, Pa., mentioned on page 729, but there seems to be no secondary enlargement of the quartz grains in this rock as is so common in that.

4210. "*Quartzite. Perry county.*"

This is very similar to No. 5036a in character. It is almost purely siliceous rock, consisting of fine-grained quartz sand in a matrix of almost aphanitic chalcedony. An occasional particle has the multiple twinning of microcline. The proportion of grains to matrix is high. No tendency toward oölitic structure was observed.

4778. "*Chert. 2 mi. w. of Glen Allen, Bollinger county.*"

A very dense, flinty rock, with a somewhat uneven fracture. Its color is pink, except on the outside, where it has weathered to a dull, pinkish white. The mass is considerably rifted and iron oxide has penetrated the cracks, staining the surfaces a reddish or yellowish brown. Some of the surfaces exposed by breaking along these rifts are covered with drusy quartz, and an occasional cavity contains small, well-terminated crystals of quartz. Under the microscope the rock is seen to be a very fine-grained chalcedony, mottled in parts by the presence of small areas and threads of more coarsely-grained material. Frequently these threads of chalcedony are connected with and seem to merge into the veins and lenses of quartz.

5005. "*Decomposed chert. L. Saline creek, Ste. Genevieve county.*"

Like chalk in appearance, but firm, rather hard and compact, with uneven, subconchoidal fracture. It is adherent to the tongue. In the thin section the material is seen to

consist of minute doubly-refracting particles scattered through an apparently amorphous base. The particles are chalcedony, while the base may be opaline in character. The rock is somewhat banded.

5030. "*Decomposed chert. Saline creek, N. W. $\frac{1}{4}$, Sec. 26, Tp. 41 N., 14 W.*"

Like the rock just described.

5034. "*Oolitic chert. Osage river.*"

The oolitic character of this chert is perceptible in the fresh portions, but it is made very prominent by the alteration due to weathering. The matrix has been the most vigorously attacked by decomposing agents, which have left the granules comparatively untouched at first and very conspicuous in its ochreous remains. The spherules have a definite concentric structure, but the fibres of chalcedony are not oriented, and, therefore, the spherules give no cross with the gypsum plate.

5036. "*Chert. Hilltop south of Forsyth, Taney county.*"

Three types of rock are represented under this number, and they will be designated 5036a, 5036b, 5036c, the last being described under Lower Carboniferous specimens.

5036a. This rock consists of colorless granitic (?) quartz in a matrix of chalcedony. The fracture is conchoidal. The matrix disintegrates first under the action of the atmosphere. The rock would not be classed as an oolite, because the chalcedony has not been deposited in concentric shells around the grains of quartz, though a partly successful tendency to make such shells was observed in a very few cases, and an occasional small spherule of chalcedony may be seen in the matrix between the quartz grains. The rock has been fractured and then cemented together again by chalcedony and quartz, but there was no slipping along the break, as the parts of some quartz grains traversed by the fracture were not displaced laterally. An isolated particle shows the multiple twinning characteristic of microcline. The chalcedony of the matrix is of the usual somewhat mottled granular type, and flecks of iron oxide are scattered somewhat thickly through the slide.

5036b. This specimen is oolitic in character, the spherules being of very fine-grained chalcedony, while the matrix is of more coarsely-grained chalcedony and quartz. In clefts in the rock, terminated crystals of quartz occur. The granules are mostly without a definite nucleus, but when one is present, it seems to be of chalcedony of a deeper brown than the rest. Occasionally two or three spherules coalesce within one outer shell. Concentric banding is much more strongly marked in some granules than in others, and the clearness of the negative interference cross obtained with the gypsum plate increases as the concentric character becomes more marked. In the rings, as is usual, the fibres are so short as to give no suggestion of radial arrangement unless the gypsum plate is used.

5091. "*Chert, vesicular. Near St. Thomas, Cole county.*"

This rock is somewhat oolitic in structure, but most of it would be called saccharoidal rather than oolitic. It is full of flattened ovoid cavities, which seem to be due to the removal of pebbles. Some of the rock retains the pebbles, one of which is of white quartzite, while others are calcareous, but effervesce very slowly with acid (HCl). None of the cavities seems referable to organisms for origin.

5112. "*Porous chert. Virginia mine, Franklin county.*"

This is a dense chert which has been deposited in stalactitic and mammillary forms, and is not strictly porous in texture. Some of the cavities are lined with drusy quartz. Some of these are stained green. Under the microscope the rock is seen to be mostly granular chalcedony, with some fibrous chalcedony and quartz. The chalcedony is beautifully banded around some of the stalactites and openings and beneath the drusy quartz.

B. FROM THE LOWER CARBONIFEROUS STRATA.

2989. "*Chert. Barry county.*"

A dull white rock, breaking with a rather smooth conchoidal fracture. The thin section is filled with minute, irregularly rounded, opaque spots in a colorless ground mass of chalcedony. Very small cavities of irregular shape make the rock somewhat porous and give it a rough feel. The rock would make a good whetstone. No fossils.

2989. *Chert, secondary deposition. Henderson mines. Sec. 34, Tp. 25 N., 29 W., Barry county. Analysis No. 1.*

This is somewhat similar to the rock just cited, but it looks more like a quartzite. It has an uneven conchoidal fracture, and is rough to the touch. One side shows molds of grains of sand (which may indicate its secondary character?). Under the microscope the rock is seen to be somewhat porous. The thin section is rather foggy or dusty in appearance, as is the case in very many cherts, and is mottled between crossed nicols on account of the varying coarseness of grain in the rock. No fossils.

3023. "*Chert. Grand Falls, Sec. 28, Tp. 27 N. R. 33 W., Newton county.*"

The rock is very dense and flinty in structure, and breaks with a smooth flat-conchoidal fracture. In color it is light gray flecked with white. Small, dark gray spots, which are not affected by being raised to a bright red heat, are scattered through the mass, and a tendency toward a banded structure is observable. In the thin section these spots are seen to be aggregates of very small dark brown or black specks, which are probably iron oxide. Crystallized quartz occurs sparingly. The specimen seems to be entirely siliceous.

3025. "*Chert from depth of 72 ft. Roaring Springs mine, Newton county.*" *Analysis No. 14.*

This is a very dense, flinty rock, breaking with a smooth conchoidal fracture. Its color is dark bluish gray mottled with white. Under the microscope the rock is mottled brown and white, and minute grains of magnetite (?) are scattered through the mass, or gathered into spots and bands. The rock is granular in structure, but a tufted arrangement of the chalcedony is noticeable in places, though the fibres do not seem all to be oriented in the same way with reference to the center of the tuft: *i. e.*, a fiber optically positive with reference to its length may be beside one optically negative. No fossils in this specimen.

3176. "*Chert. Sulphur Springs, Arkansas.*" *Analysis No. 19.*

This is a dark blue and brown rock containing a large percentage of crinoid stems and other fossils, which gives it a very irregular fracture. Evidence of the presence of a *Stromatopora* appears in the thin section. The chalcedony is not at all homogeneous in its appearance between crossed nicols, the mottled "mosaic" structure being very irregular, and there is present a larger amount than usual of material arranged like agate. These agate areas seem to be secondary in origin to the granular chalcedony.

3180. "*Chert. Sulphur Springs, Arkansas.*"

Like the preceding, except that through it there runs a rather irregular band which is comparatively dense, though it contains many crinoid stems. The band is marked by wavy lines, as of deposition.

3604. "*Chert. Marion county.*"

This specimen is partly a dense banded white and gray chert, which breaks with the usual smooth conchoidal fracture and contains no fossils, and partly a dull white chert containing many crinoid stems, breaking with an irregular surface and adhering to the tongue. The dull portion is very clear under the microscope, and presents a very much mottled appearance between crossed nicols, which is due to coarsely and finely granular and fibrous chalcedony and quartz. There is a tendency toward the formation of concretionary and mammillary forms in the fibrous chalcedony. The fibres do not seem to arrange themselves normally to the crinoid stems, unless such stems form part of the walls of what was a cavity at the time of the formation of the agate. This agate chalcedony and the quartz seem to have formed later than the granular chalcedony. The non-fossiliferous part of this specimen shows a mottled granular chalcedony, which looks very "dusty." In reflected light, this opaque dust is white. It is probably clayey matter.

3702. "*Calcareous chert. Porter's land, Aurora, Lawrence county.*"

Analyses No. 11 were made from other specimens from this locality, and do not represent the very calcareous chert from Aurora.

Some parts of this specimen are so full of crinoidal remains as to be a breccia of such material cemented by chalcedony, while other zones have very little calcareous matter in them. The thin section shows the usual mottled appearance, but a few radiating tufts occur and are optically negative in the direction of their length.

3706. "*Chert. Grand Falls, Newton county.*" *Anal. No. 16.*

This is another very calcareous chert, with uneven fracture. Its color is a rather dark drab, and the rock is somewhat banded from the aggregation of the fossils into zones. Wavy lines of deposition occur in the chalcedony around the crinoid stems. In addition to the crinoid stems, the slide shows sections of a branching form of *Stromatopora*, preserved as calcite. Perfect sphærocrystals of fibrous chalcedony occur in this specimen.

3712. "*Cherty limestone. Below Grand Falls, Newton county.*"

This is a drab limestone containing very irregular nodules of dark drab chert. The chert is flinty in appearance, very dense, and breaks with conchoidal fracture. The line between the limestone and the chert is not sharp, and one seems to grade into the other rapidly at the zone of contact. The two are so intimately mingled that it would seem as if they must have been formed at the same time. No organisms were observed in the chert.

No Number. "*Quartz on chert. North Star Mine, Cartersville, Jasper county.*"

A fragment of the bluish gray, flinty chert so common in this part of the Missouri zinc region. It is very dense, hard and brittle, and breaks with a very smooth conchoidal fracture. Cavities in the rock are lined with clear, terminated quartz crystals, which are up to 5 mm. and even more in diameter. The chert contains many moulds of crinoid stems, and is associated with much crystalline and crystallized sphalerite (zinc blende). A dark brown, somewhat carbonaceous, highly siliceous rock, secondary to the limestone and chert in formation, is abundantly associated with the ore-bearing chert here and elsewhere in the zinc-lead region of Missouri and Kansas. Dr. W. P. Jenney [124, p. 195] has called it "*cherokite*," but the material seems hardly worthy a distinctive name, as its microscopical and chemical characteristics show it to be merely a secondary, carbonaceous chert.

3734. "*Chert and yellow blende. Wentworth, Newton county.*"

This is one of the rich zinc-ore bearing cherts. It is very hard, and contains much crystallized quartz in small veins and pockets. In color it is white and gray and has much of the brown, secondary chert associated with it. Crinoid stems occur in this chert, and some of them have been silicified. In the thin section the rock looks as if it were made up of an older chert which had been broken up and recemented by chalcedony. The ore is not scattered through the mass in minute crystals, as in No. 5109 from the Spring City mines, but is confined to crystalline aggregates with or without the presence of the brown, secondary chert in clefts in the older rock.

3740. "*Decomposed chert. Frisco Ry. station, Webb City, Jasper county.*" *Analysis No. 9.*

The chert is somewhat porous, and the cavities have been stained by iron oxide, but there is no other particular mark of decomposition, and the material is fairly clear under the microscope. The color is yellowish white, and the fracture subconchoidal and somewhat uneven. The smaller cavities are due to the removal of crinoidal remains, but the larger ones seem hardly assignable to this cause. In the larger cavities there occur some very small cylindrical rods, one of which was 2 mm. long by .12 mm. in diameter. Some round spots in the slide look as if they might be cross-sections of these rods, but in polarized light they show no line of demarkation from the matrix. They have nuclei of brown matter surrounded by clear chalcedony, and sometimes several nuclei string themselves together with a common shell of chalcedony. It hardly seems probable that these rods are sponge spiculæ. This occurrence is unique in the whole series of chert and slides examined. In the cross-sections above referred to there is no orientation of the fibres of chalcedony, but around the cavities left by the removal of the crinoid stems there is such orientation, and the fibres are radial to the cavity and are optically negative.

3778 and 3817. "*Decomposed chert. Tucher's shaft, Turkey creek, Joplin, Jasper county.*" *Analysis No. 7.*

These specimens seem to be identical. The main portion of them is made up of porous, dead white or very light gray, cherty matter. Throughout this are scattered small nodules of dark gray, almost black, dense flint, which are spheroids, ellipsoids and masses of very irregular shape, and of all sizes up to 3 cm. or more in diameter. The light-colored, porous portion is strongly absorbent of water, is lightly adherent to the tongue, is rather harsh to the touch, and may readily be broken to pieces between thumb and finger. The rock seemed

to be composed entirely of finely granular chalcedony, the dark nodules differing from the white matrix in being free from cavities, and in being of somewhat coarser grain. Sometimes the exterior of the nodule is formed by an irregular zone of very fine-grained material, but there is not always a sharp boundary between nodule and matrix. No fossils were observed.

5036c. "*Chert. Hilltop south of Forsythe, Taney county.*"

This is a light brown, very dense rock, but it contains many moulds of crinoid stems and plates. Under the microscope the rock is seen to be an extremely fine-grained chalcedony, somewhat mottled. It contains many minute particles of iron oxide.

5051. "*Chert above crinoidal layer. Near Chadwick, Christian county.*"

This is a dense, grayish white chert with an occasional cavity in it, or an area of looser sandy material which may be easily scraped out with the knife. The rock shows no effervescence with HCl. An outer shell of alteration, 3.5 to 5 mm. thick, is softer than the unaltered part, and is stained light brown with iron oxide. No fossils.

5060. "*Chert, crinoidal. Four miles south of Kerbyville, Taney county.*"

A light brown chert, containing many moulds of crinoidal remains. In the thin section certain reticulated areas were noted which may be some form of *Stromatopora*. The rock is a finely granular chalcedony.

5070. "*Chert. Locality?*";

This was a nearly perfect ellipsoid, the only one of that form in the collection. Its color is pearl gray in concentric rings of different shades, and it is mottled with spots of darker gray. The rock is very dense, has a subvitreous lustre and breaks with perfect conchoidal fracture. Under the microscope the spots are seen to contain more iron oxide than the surrounding material, and the darker ones show many grains of magnetite (?). The thin sections show the chalcedony to be much finer in grain perpendicular than parallel to the radii of the nodule, which would indicate that the minute grains are really very short fibres arranged with their length radial to the nodule, but the fibres are not oriented alike optically. No free quartz was observed in the specimen, and no organic remains except one fragmentary cast, doubtfully referred to a bivalve shell.

5109. "*White secondary chert and blende. Spring City mines, Sec. 10, Tp. 26 N., R. 33 W., Newton county.*"

Two parallel fossiliferous layers traverse the specimen in hand, about two inches apart, but only crinoid remains were identified among the fossils. The color of the chert is light bluish gray, with very narrow veins of white running through it in all directions. The banded character of the rock is brought out by differences in color and by the arrangement of crystals and small masses of sphalerite in more or less distinct layers. The cavities left by the removal of the crinoid stems frequently contain crystals of sphalerite, indicating the secondary origin of the ore. In the thin section the ore appears scattered through the rock in small particles, and would seem to be partly contemporaneous with the silica in deposition. The chalcedony is mottled granular as usual, and incloses some areas of crystalline quartz. Compare with No. 3734.

5115. "*Porous chert. Alba mines, Jasper county.*"

The rock is very light gray in color, stained with iron oxide on the outside of the block to a depth of from 3.5 to 7 mm. The porous character of the rock is due to innumerable small cavities left by the removal of crinoidal remains. These cavities give the rock an uneven fracture. The rock now consists entirely of chalcedony of the type usually seen in these cherts. The grains are larger around the cavities than elsewhere in the matrix, and are arranged normally thereto. The grains or fibres are optically negative with reference to their length.

APPENDIX B.

METHODS OF ANALYSIS

PURSUED IN THE DETERMINATION OF MINUTE QUANTITIES OF METALS IN CRYSTALLINE AND CLASTIC ROCKS.

By James D. Robertson.

There have been a number of attempts made by various geologists to determine minute quantities of metal in country rocks, in connection with investigations regarding the origin of ore deposits. Such have been confined in this country largely to the determination of small quantities of gold and silver, but examinations for other metals have been made also [54, p. 136 *et seq*] [78], while numerous experiments have been made on the solubilities of the various associated minerals [10].

The rocks in which the lead and zinc deposits of Missouri occur are of Lower Silurian and Lower Carboniferous ages. These Paleozoic clastics having been originally derived from the crystalline rocks, it was considered advisable to examine a few samples of these latter; consequently specimens of granite, porphyry and diabase were also collected for analysis.

In selecting the specimens of these rocks for analysis, great care was exercised to get them entirely free from visible admixtures of ore.

The treatment after the rock samples are dissolved is essentially the same with both the limestones and the crystallines; hence the process of getting the samples of both into solution will first be considered separately, after which the treatment of the solutions will be described.

Crystalline rocks.—Of the igneous or crystalline rocks, ten grams were used, finely powdered. This sample was weighed into a platinum dish and treated with hydrofluoric acid and heated gently; when nearly dry, more acid was added and the evaporation again carried almost to dryness. The mass was then washed into a beaker, concentrated hydrochloric and nitric acids added, and heated strongly for about half an hour. It was then filtered, and the residue again treated with hydrofluoric acid and fused with potassium disulphate. The fused mass was dissolved in water, with the aid of a little hydrochloric acid, and filtered into the previous solution, which was then treated as described later.

Limestones.—One hundred grams of limestone, crushed to about 1-30 inch and finer, were weighed out and dissolved in dilute hydrochloric acid. The supernatant liquid was poured off as it became saturated with calcium chloride. With dolomite and also with some limestones it was found well to dissolve at a gentle heat. When

all the soluble matter had been dissolved, the residue was filtered off. This was then dried, ignited, treated with hydrofluoric acid in a platinum crucible, and finally fused with potassum disulphate. The fused mass was dissolved, any residue remaining being filtered through a small ashless filter, burned, fused with sodium carbonate, and, from the solution of the last-fused mass, barium sulphate precipitated out. On account of the large amount of lime in the original solution of the limestone, it was impracticable to add the solution of the residue to it, because of the sulphates present. So they were each subjected to the same treatment until the metals were precipitated as sulphides from each, when they were united, as will be explained later.

Treatment of the solution —The solution was neutralized with ammonia, about 10 grams of ammonium chloride having been added. In the case of the first solution of the limestone, it was frequently noted that, while most of the organic matter in the limestone separated out in the residue, some was apparently dissolved by the hydrochloric acid. Under what conditions this action takes place is not known, but it certainly exercises a reducing action on the iron, and renders it necessary to heat the solution with nitric acid for about 30 minutes before neutralizing.

The hydrous oxides of alumina and iron were filtered off, dissolved and reprecipitated three times and all the filtrates united. The combined filtrate should be not less than one litre in the case of the crystalline rocks, nor less than two litres in the case of the main solution of the limestone, while the filtrates from the solution of the residue of the latter should be only about half a litre. The hydrous oxides of iron and alumina are both somewhat soluble in ammonia, even in presence of ammonium chloride; so small quantities of these salts were invariably in this filtrate, but this was found to be an advantage, rather than otherwise. These heavy metals were then precipitated from this filtrate as sulphides, by the addition of ammonium sulphides—the iron and alumina aiding mechanically in collecting the small quantities of these precipitates. The sulphides were next decanted on to a rather small filter, care being taken to keep all the vessels covered so as to prevent the oxidation of the sulphides. Ammonium sulphide is very liable to absorb carbon dioxide from the air, so that when all the liquid has been poured on to the filter, a residue of carbonate of lime will be noticed in the beaker. This was dissolved in hydrochloric acid, neutralized with ammonia, and any trace of the metals was precipitated by ammonium sulphide. The precipitate of sulphides from the solution of the limestone, and that from the residue, were caught in the same filter, and were thenceforth treated together.

The sulphides of the metals were dissolved in boiling, dilute, nitric acid, the filter paper burned, the residue dissolved in nitric acid and added to the solution. This solution was neutralized carefully with ammonia, ammonium chloride having been added, the excess of ammonia driven off by heat, and the hydroxides of iron and alumina filtered off; these were redissolved and precipitated again and the filtrate added to the first one. The filtrates were evaporated to about 100 c c, ammonia and ammonium sulphide added, and the sulphides of lead, zinc, copper and manganese filtered off. This precipitate was dissolved in hot, boiling nitric acid, a little sulphuric acid added to the solution, which was then evaporated until fumes of sulphur trioxide were seen. Dilute alcohol was then added, and the lead was filtered off as sulphate and washed with alcohol.

The filtrate was next evaporated nearly to dryness to destroy the alcohol; hydrogen sulphide was passed through to precipitate the copper, which was then filtered off and burned in a Rose crucible (into which hydrogen sulphide was passed) and weighed as sulphide.

The remaining filtrate was rendered alkaline by addition of ammonia, and the sulphides of zinc and manganese were precipitated by ammonium sulphides. These sulphides were digested in acetic acid, which dissolved the manganous sulphide and left the zinc sulphide untouched. The precipitate of zinc sulphide was caught on a filter, ignited and weighed as zinc oxide. This was frequently, though not in all cases, dissolved and reprecipitated as the carbonate and weighed. The difference was seldom appreciable.

The filtrate was heated to boiling, the manganese precipitated as carbonate by sodium carbonate, filtered off, washed thoroughly with hot water, dried, ignited and weighed as mangano-manganic oxide (Mn_3O_4).

Thus we obtained from the solutions of these rocks the percentages of lead, zinc, copper and manganese. When the final solution of the residue was made, any barium present in the rock was left undissolved as barium sulphate. To ensure the purity of this, the slight residue on the last filter was fused with sodium carbonate, the mass dissolved in dilute hydrochloric acid, and the barium precipitated with sulphuric acid. This was collected on a small ashless filter, ignited and weighed.

The results show a remarkable uniformity, the agreement of the duplicates being very close. The determination of copper is not so accurate, the compound resulting, (*i. e.*, cupric sulphide,) affording chance for variation.

It is very necessary that the reagents used should be of the purest. Blank determinations were made in the present case, in which the same amounts of the reagents as entered into the regular analysis were used.

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